KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KUMASI
COLLEGE OF AGRICULTURE AND NATURAL RESOURCE DEPARTMENT OF AGRIC ECONOMICS, AGRIBUSINESS AND EXTENSION

ASSESSING THE FACTORS INFLUENCING IPM ADOPTION IN GHANA: THE CASE OF VEGETABLE FARMERS IN THE KUMASI METROPOLIS

ISAAC KAKRABA LARBI (MPHIL AGRICULURAL ECONOMICS)

THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL ECONOMICS, AGRIBUSINESS AND EXTENSION, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

MPHIL AGRICULTURAL ECONOMICS

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DECLARATION

I hereby declare that this thesis is my own work towards the Master of Philosophy (MPhil) degree in Agricultural Economics and that, to the best of my knowledge, it contains no material previously published by another person nor material which has been accepted for the award of any other degree of the University, except where due acknowledgement has been made in the text.

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DEDICATION

This work is also dedicated to my parents, Mr. David Ofei Larbi and Mrs. Gify Appiah for their profound contributions throughout my study, and all my course mates for their little but cherished contributions to this work. The good Lord blesses them

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Finally, I thank God for his love and guidance.

ABSTRACT

Integrated Pest Management (IPM) is an approach used to enhance crop production. Although most IPM practices or technologies have proven to be relevant, their adoption have been found to be less among smallholder farmers in sub-Saharan Africa, including Ghana. This study examines the adoption of two IPM practices, namely, pesticide application and pest monitoring with a cross-sectional data collected on 300 vegetable farmers from five vegetable farm sites in the Kumasi metropolis of Ghana in 2012. The multinomial logit model was employed in the empirical analysis to examine the factors which influence the adoption of the existing IPM practices among the vegetable farmers. The empirical results indicate that age, education, membership of FBO, farm size, contract farming, employed hired labour, availability of hired labour, perception of labour cost and extension visit had positive influence on adoption of pesticide application only. Household size, dependency ratio, distance traveled to pesticide sale point had negative effect on pesticide application only. For the adoption of pest monitoring only; age, farm size, contract farming, employed hired labour, availability of hired labour, perception of labour cost and extension visit had a positive effect on its adoption. Distance traveled to pesticide sale point had a negative effect on its adoption. The results also indicate that education, access to credit, membership of FBO, farm size, contract farming, employed hired labour, availability of hired labour and extension visit had a positive effect on the adoption of both practices. Distance traveled to pesticide sale point and access to credit facility had a negative influence on the adoption of both practices. It is recommended, based on the empirical magnitudes and directions of the determinants that the government will draw policies to accommodate some of the input cost through subsidies so that farmers can channel the money spent on input to hiring more labour. Also FBO should be included in IPM training programs

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LIST OF ACRONYMS

ABBREVIATIONS	DEFINITIONS
CODAPEC	Cocoa Disease And Pest Control
CGIAR	The Consultation Group on International Agriculture Research
CSIR	Council for Scientific And Industrial Research
EPA	Environment Protection Agency
FAO	Food and Agriculture Organization
FBO	Farmer-Based Organization
FFS	Farmers Field School
IFPRI	International Food Policy Research Institution
ILO	International Labour Organization
IPM	Integrated Pest Management
MoFA	Ministry of Food and Agriculture
NGO	Non-Governmental Organization
POC	Project Oversight Committee
WARDA	West Africa Rice Development Association
WHO	World Health Organization
VAT	Value Added Tasks

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Though widely promoted as sustainable means of pest control there is no general agreement on its definition (Orr, 2003). The Consultation Group on International Agriculture research (CGIAR) defines Integrated Pest Management (IPM) as an approach to enhance crop production based on the understanding of ecological principle that empowers farmers to promote the health of crops with a well-balanced agro-ecosystem making full use of available technology. IPM represent a change from pest eradication towards pest management, thus the management of an entire pest population not just a localized one and instead of single control technique. IPM emphasizes on the use of a combination non-chemical method and judicious use of chemical input in production aimed to provide cheap but long term reliability with minimum of harmful effects (Rabb, 1970 cited by Dent, 1991). IPM technology was further explained by Beckmann and Wesseler (2006) as a method that include the integration of biological, mechanical, cultural and pest management practices based on continuous pest monitoring.

This technology was introduced to curb the increasing use of pesticide and its effect in the agricultural production stream during 1940 to 1960 periods in Europe and USA (Taylor *et al*, 1991). This is the same in Ghana and this increase in pesticide use is much prevalent in vegetable production. Evidently, Gerken *et al* (2001), states that increasing pesticide use is concentrated on vegetable and other cash crop production; vegetable farming is fraught with abuse, misuse and overuse of pesticides and it is estimated that 87 percent of farmers in Ghana use chemical pesticides to control pests and diseases on vegetables (Dinham, 2003). Of the pesticides used, 44%

are herbicides, 33% are insecticides and 23% are fungicides (Ntow *et al*., 2006). Braima *et al* (2010) reveal that the pesticides used by vegetable farmers are either banned or very toxic according to the WHO classification of pesticide.

Together with the IPM technology, other various strategies were also put in place to mitigate the effect of pesticide use. These strategies include, banning of toxic pesticide (Taylor *et al*, 1991), the imposition of valorem Tax and VAT on pesticide (Agne, 2000). The strategies with the exception of the introduction of IPM proofed ineffective because:

Banning of agro-chemicals was to annihilate the usage of toxic chemical in our production system but these banned agro-chemicals are still found in the production system proofing the ineffectiveness of that strategy (Machipisa, 1996). Addition of valorem tax which would affect voluntary reduction in pesticide use by increasing the private cost more nearly to the social cost (Shumway and Chesser, 1994) has been recorded by Agne (2004) as effective in reducing pesticide use but Gerken (2001) explains that pesticide imported into Ghana have their tax been scraped from it, therefore the country is not enjoying the advantage of this strategy or measure, but IPM, proving to be effective, was recommended globally for increasing agricultural production without upsetting the balance of nature while controlling pest (Bonabana-Wabbi, 2002). Hussan *et al* (2001) also explained that for sustainable and profitable production in developing countries, IPM technology is an appropriate method which can reduce and minimize the use of pesticide as well as reducing the cost of production.

Sunding and Zilberman (2001) characterized IPM as a dissembled technology; that is (1) complex and knowledge intensive (2) labour and managerial intensive.

Its complexity and knowledge intensity to farmers makes it difficult for a farmer to apply the IPM measures therefore resulting in the reduction of the adoption of the technology (Beckmann and Wesseler, 2006). Because of this an increasing number of developmental agencies including FAO, International labour Organization (ILO) and WHO observe that priority should be given to education of pesticide users and promoting system that restrict pesticide use (Weber, 1996). This was done by the implementation of the Farmers Field School (FFS) (Schmidt *et al*, 1997). Caswell, *et al*., (2001) ascertains that high levels of farm operator education are likely to induce adoption of management technologies. This FFS approach is to train farmer in IPM during the cropping season so that they can compare the result at the end and with an expectation that farmers will adopt some of the IPM technique learned (Horstkotte-Wesseler, 1999). FFS IPM training has been reported to have a significant impact on farm yields and profits and decline in pesticide use (Van den Berg and Jiggins, 2007).

In terms of labour and managerial intensity, an IPM strategy substitute's capital (expenses and pesticides) and labour time spent on spraying for labour time spent on the implementation of IPM measure (Fernandez-Cornejo, 1996; Morse and Buhler, 1997; Schillhorn van Veen *et al*., 1998; Pingali and Gerpacio, 1998; van de Fliert and Proost, 1999). Beckmann and Wesseler (2006) state that farmer who wants to adopt IPM technology is likely to adopt IPM practices that fit well within the capacity of the labour used on his farm or, rather, reform farm labor in a way that is suitable for IPM and does not simply hire additional labor to perform IPM practices.
Therefore Labour-related indicators are central to evaluating the viability and sustainability of IPM (Lee *et al*., 2006).

The adoption of IPM technology which is being advocated for, by all countries seeking to improve its agricultural sector in sight of the above characteristics stated by Sunding and Zilberman (2001), is influenced by age of operator, size of operation and specialization as important factors (El-Osta and Morehart, 1999). Rogers (1995) demonstrates that adoption of technologies depends on their characteristics: compatibility with the existing values and norms, complexity, observability, trialability, and relative advantage and this definition pertains to technologies in a variety of disciplines, and may be as relevant in other fields as it is in agricultural related technologies. Others say lack of adequate inputs and active information (Feder and Slade, 1984) may be obstacles to adoption. The adoption of a technology (not excluding IPM) is also based on its profitability and profitability of a new technology is determined by attributes of the technology and a number of farm-specific factors, such as farm size, risk and uncertainty, human capital, labor availability, credit constraints, information constraints and supply constraints of complementary inputs (Feder *et al*., 1985).

IPM technology is being advocated to be adopted because of its merits or profitability. Economic theory suggests that, a practice that proves to be profitable is likely to be adopted by producers. Yet according to Giliomee (1994), IPM, a profitable venture, has not been widely adopted. This non-adoption has led to this study to seek to identify the effect of factors affect the adoption of two important practices in the technology. These include pesticide application and pest monitoring.

These two are integral part in the technology because pesticide application cannot be done away with in the controlling of pest in agriculture (Knutson, 1999). He (Knutson, 1999) also state that, if pesticide where to be eliminated, there will be other negative effects imposed in the production of crops. Also Beckmann and Wesseler (2006) identifies that the result from the pest monitory is the key element in IPM implementation.

1.2 Problem Statement

In many developing countries, including Ghana, farm chemical inputs play a large role in agricultural production, especially because of the need to increase production. Unfortunately the use of some of these inputs is associated with degradation of the environment, and health of living organisms, including humans (Pina and Forcada, 2002). Mitigating the effects of these "necessary evils" therefore became a focus for many research programs. Alternative methods of production that reduces negative effects of chemicals and maintain at least the same level of production are continuously sought after. Alternatives such as cultural methods, organic, and biological control methods are increasingly emphasized to improve land productivity and control of pests.

One such alternative is Integrated Pest Management (IPM). As mentioned earlier, the IPM approach emphasizes the use of non-chemical inputs and judicious use of chemical inputs in production to reduce pest incidence on crops, thereby increasing farmers' yields and returns. This approach is recommended globally for increasing agricultural production without upsetting the balance of nature while controlling pests. Although some literature indicates uncertainty of IPM profitability (Abara and Singh, 1993), or profitability of some, but not all parts of the total package (Smith *et al*, 1987), several studies (Jago, 1991; Dent, 1991; Emden and Peakall, 1996) demonstrate the benefits accrue from IPM. These include its effect on reducing pesticide residue on crops, lessening the negative impacts of pesticides on the environment and humans, lowering production costs, and increased pest management effectiveness (Bonabana, 2001). Also a deduction using a linear programming model developed on a national level indicated that widespread adoption of farming practices with minimum use of pesticides (and fertilizers) would increase net farm incomes in the US (Bonabana, 2002). IPM introduced in Africa has its own accrued benefit: Youdeowi (2002) state that Ghanaian farmers adopting IPM have increased their yield over 50%, income over 30% and reduced their pesticide use by about 90% and also an average net return of 138% higher than the non-adopter. The introduction of IPM practices to control cassava mealy bug which caused over 80 percent loss in tuber yield, became successful over 22 countries in Africa with a benefit-cost ratio of 178:1 with return of about US$20 million (Emden and Peakall, 1996). Emden and Peakall (1996) also state that the introduction of IPM practices in West Africa, WARDA programs, has led to the elimination of Euphorbia heterophylla, one of the most difficult weeds of upland rice. Thus from the above IPM has been demonstrated to be potentially profitable and in such cases society can benefit from its adoption.

Economic theory suggests that the practices proved to be profitable are likely to be adopted by producers. Yet according to Giliomee (1994), IPM, a profitable venture, has not been widely adopted. For instance, only 4% of all US farms are said to practice 'true IPM' (Ehler and Bottrell, 2000), and Ghana is no exception because the FAO cooperate document titled, "World Agriculture: Towards 2015/2030. An FAO perspective national policy framework" states that in many developing countries have tended to strongly favor pesticide use through subsidies that distorted prices. Because of this, alternative pest control measures, even where successful technically, are often not financially competitive and farmers are reluctant to adopt them. It is also stated that only a few farmers use the IPM packages (Kyamanywa, 1996). Moreover, extent and level of IPM use in Ghana is still largely unknown says Gerken *et al* (2001). Also in terms of level of adoption of IPM, Gerken *et al* (2001) reveals that no organized action at the national level has been put in place for IPM. This issue of not adopting IPM technology, even though it is profitable, has led to the investigation of the factors, influencing its adoption focusing on two important practices; pesticide application and pest monitoring.

1.3 Research Question

The pertinent questions that this study seeks to answer are:

1. What are the awareness level and perceptions of vegetable farmers on IPM practices?
2. What factors influence the adoption of IPM practices by the vegetable farmers?
3. What are the gross margin of adopters and non-adopters of IPM practices in vegetable farming?
4. What are the constraints to the adoption of IPM practices by vegetable farmers?

1.4 Objective of the Study

The main objective of the study is to access the influence of factors effecting the adoption of IPM practices. The specific objective is as follows:

1. To determine the awareness level and perception of vegetable farmers on IPM.
2. To determine the factors influencing the adoption of these IPM practices
3. To determine the gross margin of adopters and non-adopters the IPM.
4. To determine the constraint to adopting IPM practices by vegetable farmers

1.5 Justification of Study

Pesticide use in agriculture play an important role in agriculture productivity but also acts as a double edged sword as describe by Taylor *et al* (1991). It is being described as "double edged sword" because pesticide cannot be done away with in the control of pest attack and yield loss and on the other side of it; it poses a threat on human health, wild life and the ecosystem in general. Evidence of it merit can be obtain from the work of Carrasco-Tauber (1992),who states that, for a dollar spent on pesticide, the farmer can reduce crop damage by 3-5 dollars, Noorwood and Marra (2003) also state that pesticide use have a positive marginal productivity. For its demerit, Willson and Tisdell (2001) state that the use of these chemical has negative externalities on human health and the environment which range from pollution to skin irritation to death. Because of it merit, the government tried to boost up yield through intensification and structural change which led to an increase in pesticide use (Gerken *et al*, 2001). Also farmer on the other hand has tried to reduce pest attack and crop lost by the application of pesticide based on the advice of extension officers (Davis, 1997). These pesticides use according to Gerken *et al* (2001) is concentrated on vegetable and other cash crop production and has led to the surfacing of the negative side of pesticide use. To curb these negative, regulation have been put in place to annihilate the use of some very toxic pesticide but Knutson (1999) suggested that a complete elimination of the pesticide use of these chemicals will be to a disadvantage, therefore a reduction of pesticide use will be the best alternative.

Out of a group of alternative methods to reduce pesticide use below the economic threshold level, Hussan *et al* (2001) explained that IPM is the best for reduction of pesticide use, sustainable and profitable production in agriculture. Therefore the studies into the factor having effect on the adoption of IPM technology is pre-eminent because it will serve as an indication of how to affect the rate at which pesticide use is being reducing. Also the in study, factors considered to affect IPM adoption will give IPM administrators and researcher knowledge which will serve as guidance to enhance program effectiveness. Thus, they will be able to make inform decision on how to intensify IPM adoption rate will lead to a reduction in pesticide use.

Another benefit from the research will be provision of an explanation of the current state of technologies used by farmers. Moreover, since IPM involves a variety of practices that are specific to individual crops, measuring its adoption on vegetable may provide a strong case for increasing investment in various IPM research.

The results will provide useful information to enhance the success of the IPM adoption, and any other related program that attempts to introduce practices for adoption in settings that are similar to those in this study area. Results of this study will thus have implications well beyond the confines of the study area.

1.6 Organization of the Study

This study is organized into five chapters. Chapter one has introduced the study Chapter two reviews the relevant literature on IPM adoption. Chapter three presents the methodology employed in the study. Chapter four discusses the descriptive and empirical results of the study. Chapter five provides the conclusions of the study, and makes some policy recommendations on IPM adoption in Ghana based on the findings from the study.

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews literature on the concept of integrated pest management, principle of integrated pest management, vegetable production and pesticide use, integrated pest management (IPM) in Ghana and empirical literature on the adoption of IPM practices.

2.1. The Concept of Integrated Pest management (IPM)

The concept of Integrated Pest management (IPM) was first conceived after World War II when it was determined that a control system was required to check overuse or abuse of pesticides used to control major pests of cotton in the USA. It required a compatible control strategy, which was a mix of biological and reduced chemical control tactics. In 1972, IPM was formulated into national policy and under US president Jimmy Carter; an interagency coordinating committee was formed in 1979 to ensure development and implementation of IPM practices (Ehler and Bottrell, 2000).

The focus of IPM research is to reduce pesticide usage on crops while maintaining a high level of pest control. In general, IPM calls for a greater reliance on non-chemical approaches to pest management (IFPRI, 1998) while maintaining agricultural production and preserving profitability (Mullen, Norton and Reaves 1997). In doing this, IPM encourages strategies that include greater dependence on biological approaches, cultural approaches and judicious use of some pesticides. A broader definition of IPM is that given by Wightman (1998):

"IPM consists of management activities carried out by farmers that maintain the intensity of potential pests at levels below which they become pests, without endangering the productivity and profitability of the farming system as a whole, the health of the farm family and its livestock and the quality of the adjacent and downstream environments." (Wightman, IFPRI homepage, 1998). Pests have been known to attack crops virtually at every stage of crop development: at pre-germination, budding, flowering, harvest and in post-harvest/storage thereby leaving the crop with no "breathing space." This necessarily calls for pest control.

Various methods of pest control can be categorized into two broad groups: Chemical and nonchemical - each with its advantages and disadvantages. The range of non-chemical options is diverse, including biological control, cultural control, plant host resistance, sanitation and genetic transformations. Biological control, the use of natural enemies of pests and entomopathogens is somewhat limited in its applicability and its application for subsistence level farming although the potential for expanding its use is great (Jackai, *et al*., 1985; Pimentel, 1986).

Chemical means have a number of benefits like ease in application (although not necessarily safe application), effectiveness and fast action on target pests. However, their disadvantages, especially in interfering with the ecosystem, are well documented. Cultural methods include manipulation of planting dates and cropping patterns, such as crop diversity and crop rotation. These methods achieve their pest control abilities from having one or more crops in the rotational sequence that are resistant to a key pest. For weed suppression, the success of rotation systems appears to be based on the use of crop sequences that create varying patterns of resource competition, soil disturbance, and mechanical damage to provide an unstable and frequently inhospitable environment that prevents the proliferation of a particular weed species, (Liebman and Dyck, 1993).

Rotations offer an opportunity to increase production, either through direct yield increases or through reductions in some of the inputs required for the present or next crop. Greater benefits are usually obtained by rotating two distinctly unrelated crops. Crop diversity makes the environment less favorable to certain pests while manipulation of planting time avoids reduction in yields caused by pests. In addition, cultural controls are far less ecologically disruptive than the standard chemical control practices. However, cultural methods are often labor intensive (Pimentel, 1986).

Considering that most subsistence farms use family labor, one might infer that this should not be a problem. However, with the fast paced life that is expected in the near future, and the subsequent value of time, these two resources: time and labor will become constraints to cultural control means. Furthermore in subsistence production systems, family labor is often in short supply at times such as sowing, weeding and harvesting. In addition, these methods may have added risks. For instance, in a bid to control the known pests, altering planting time may create a more favorable environment to more destructive pests. Also planting time manipulations may be constrained by climatic changes. Moreover the effectiveness of these cultural methods is highly unpredictable (Pimentel, 1986). In general, each method (biological, cultural or chemical) may contribute to pest suppression. However, no one method provides satisfactory results. Hence, an integrated approach that avoids the use of a single control tactic is necessary. In effect when several methods are employed, the amount of each component (biological, cultural chemical), including the use of pesticides in the package may be reduced (Jackai*et al*., 1985).

2.2. Principle of Integrated Pest Management (IPM)

Though widely promoted as sustainable means of pest control there is no general agreement on its definition (Orr, 2003). The revised International Code of Conduct on the Distribution and Use of Pesticides, FAO (2002) defines IPM as follows: "IPM means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment". According to consultation group on International Agricultural Research (CGIAR) IMP can also be define as an approach to enhance crop production based on understanding of ecological principle that empower farmers to promote the health of crops within a well balance agro-ecosystem making full use of available technology Morse and Buhler (1997) explains that IPM was developed as a response to the health and environmental problem related to misuse of agro chemicals. Youdeowi (2000) also explains it as a system combining all available methods to ensure the healthy growth of crop plants. Beckmann and Wesseler (2006) stated that the available methods include the integration of biological, mechanical, cultural and pest management based on continuous pest monitoring. Result from the pest monitory is the key element in IPM implementation.

Emden and Peakall (1996) explain that the pest mismanagement translates into the following aspects of IPM thus the use of economic thresholds to give guide spraying decision, when pesticides are needed, they used in a way that is least damaging to biological control and Introduction of cultural practices if it is compatible with the farm management system

2.2.1 Economic Threshold

Stern *et al*, cited by Emden and Peakall (1996) defined economic threshold as the density at which control measure should be determined to prevent an increasing pest population from reaching the economic injury point. The economic injury point they define as the lowest population level that will cause economic damage. The threshold level may be related to the beauty, health, or economic value of the crop (Youdowei, 2000).

To identify the economic threshold level of a farm, insect sampling is carried out which is called monitoring or scouting. This is preeminent before pesticide application because it makes farmer and pest managers to understand pest activities in the crops and field before making a cost effective and environmentally sound pest management decision (Geoffzehnder, 2010). The main purpose behind pest monitoring according to Geoffzehnder (2010) are detect species that are present, to determine population density and to determine how they are distributed on the field.

Monitoring for pests is recommended for each crop. Monitoring is done week to determine presence, density, and locations of pests and to determine crop growth stage. In monitory, record keeping is also required. In scouting, the appropriate monitoring aids such as pheromone traps, weep net, disease diagnostic tests is required (http://www.nysipm.cornell.edu/elements/default.asp). The use of on-farm weather monitoring devices to measure precipitation, humidity, temperature, and leaf wetness and/or use commercial weather prediction service for prevention and control of plant diseases. (Example: Install weather station with rain gauge, hygrometer, maximum and minimum temperature recording equipment, leaf wetness sensors) is helpful in the determination of the threshold level (http://www.skybit.com/).

2.2.2 Pesticide Use

Pesticides are a very important tool in IPM when large pest populations exceed the threshold level crops. Knowledge of the pest's life cycle, selection of an appropriate pesticide, proper timing of the application, and use of the right application equipment will improve the control of pest population and impact (Youdowei, 2000). Selection of pesticides, formulations, and adjuvant should be based on least negative effects on environment, beneficial (e.g., pollinators, predators, parasites), and human health in addition to efficacy and economics (http://nysipm.cornell.edu/publications/eiq/default.asp)

Cultural practice

Cultural management manipulates the environment to make it more favorable for the plant and less favorable for the pest. Cultural controls make it less likely that the pest will survive, colonize, grow, or reproduce. Cultural management can be very effective in preventing pests from building to unacceptable levels (Youdowei, 2000). Cultural practice include Use cover crops, especially pest-suppressing crops (allelopathic), in the rotation cycle to reduce weeds and disease incidence and to improve soil quality (http://www.umass.edu/umext/ipm/guidelines/index.html). Plant using appropriate within - and between-row spacing optimal for crop, site, and row orientation also form a cultural practice in IPM technology (http://www.nevegetable.org/). The use of mechanical pest controls such as cultivate use, mow, hoe, and hand removal of insects and weeds, prune diseased or insectinfested plants, removal of diseased plants can be implemented. Also use of physical pest controls and deterrents example: Use flame weeding or other heat methods for insect, disease, and weed control; noise-makers; reflectors; ribbons; and predator models (http://attra.ncat.org/attra-pub/PDF/IPM/weed.pdf).

2.3 Vegetable Production and Pesticide Use

Consumers demand for vegetables the world over have recorded a remarkable increase partly due to urbanization. This can be attributed partly to the important part vegetables play in the healthy diet and if sufficiently consumed in daily amounts could help prevent major diseases such as coronary heart diseases and cancers (Renaud *et al*., 1995). Vegetable production is typified by urban and peri-urban agriculture (Oboubie *et al*., 2006). In Africa, vegetable production is important component of the daily diet and important source of income, especially in the urban and peri-urban area (Briama *et al*, 2010). Vegetables grown are grouped into three type based on the part being consumed and sold. They include, leafy vegetable, fruit vegetable, and root vegetable (Briama *et al*, 2010). Particularly the major vegetables grown in Ghana are tomatoes, onion, shallots, okra, eggplant, 2spinach, sweet and chili pepper, cabbage and lettuce (Sinnadurail, 1993).

To focus on the study area, Kumasi, there are about 41 ha in the urban area under vegetable irrigation1 while the peri-urban area has more than 12,000 hectare under irrigated vegetable farming mostly during the dry season (Cornish and Lawrence, 2001), twice as much as under formal irrigation in the whole country. Briama *et al* (2010) vegetables are commonly grown in the rainfed upland ecologies and lowland ecologies such as bololand, riverine, inland valley swamp but in West Africa vegetable production for urban and peri-urban area, rainfed upland ecologies are popular. Because of the Agro ecosystem of the production site for vegetable cultivation, a wide range of organism are attracted to it, some of which are beneficial and others are harmful (Briama *et al*, 2010). These harmful pests contribute to the loss of yield. Africa's overall crop loss due to pests stands at an astonishing 96.2% of its production (Oerke*et al*., 1994) and Ghana is not excluded.

To boost up yield by the government through intensification and structural change has led to an increase in pesticide use (Gerken *et al*, 2001). Farmer on the other hand has tried to reduce pest attack and crop lost by the application of pesticide based on the advice of extension officers (Davis, 1997). These pesticides use according to Gerken *et al* (2001) is concentrated on vegetable and other cash crop production. Vegetable farming is fraught with abuse, misuse and overuse of pesticides. It is estimated that 87per cent of farmers in Ghana use chemical pesticides to control pests and diseases on vegetables (Dinham, 2003). Of the pesticides used, 44 per cent are herbicides, 33 per cent are insecticides and 23 per cent are fungicides (Ntow *et al*., 2006). James *et al* (2010) reveal that the pesticides used by vegetable farmers are either banned or very toxic according to the WHO classification of pesticide.

The application of pesticide has been effective in controlling pest and reducing yield lost. Carrasco-Tauber (1992) stated that for every dollar spent on pesticide, the farmer can reduce crop damage by 3-5 dollars. Shumway and Chesser (1994) reveal that pesticide application has contributed to a major increase in the productivity. Works of Noorwood and Marra (2003), Brorsen and Teague (1995) supports by stating that pesticide use have a positive marginal product. Because of the effectiveness of pesticide in controlling pest, its use has continued to increase over time (Olesen *et al*, 2003). Due to this increase in pesticide use, its market has become a matured one with a growth rate of about 1-2% per year (Berenbalum, 2000).

Below is a table illustrating the trend of increasing pesticide demand in Ghana.

Table 1: Agro-chemical Imports (Mt)

Agro-chemical	2000	2001	2002	2003	2004	2005	2006	2007	2008
Insecticide	1195	907	1090	5829	610	5982	6921	9979	5121
Fungicide	673	618	1345	1678	770	1713	2575	2575	2767
Herbicide	224	598	582	2472	1096	5340	8932	8932	10835
Rodenticide	257	384	563	159	n.a	13	78	123	n.a
Total	2349	2507	3580	10133	2476	13048	17927	21609	18723

Source: GSS, Accra n.a: figures not available

Agro chemicals used by farmers has been described as a "two edged sword" (Taylor *et al* 1991). This is because pesticide use, although effective in controlling pest and reducing yield loss, has also negative externalities on human health and the environment (Wilson and Tisdell, 2001). These externalities range from pollution of the environment (Baffour and Mensah, 1993) to skin irritation to death for human (www.pestrd.pdu.edu).

To reduce the alarming increase in pesticide use, various strategies have been brought up and this include, banning of toxic pesticide (Taylor *et al*,1991), the imposition of valorem Tax and VAT on pesticide (Agne, 2000) and the introduction of the IPM technology (Reddy, 2006).

Banning a chemical is to ensure that it is prohibited to sell or buy this chemical. This is to annihilate the usage of toxic chemical in our production system. Banned toxic pesticides are still found in the production system, proofing the ineffectiveness of that strategy. Machipisa (1996) reports that some US companies export banned pesticide into the third world countries and Smith (2000) states that these exports include 27 million pounds of banned pesticide from the USA.

Knutson (1999) explains that, if pesticide where to be eliminated, it will also have side effects. These effects include; (1) the broader the group of pesticide elimination the greater the yield impact. Fruit and vegetables which are more dependent on pesticide are adversely affected through the yield reduction. (2) The elimination of pesticide will cause a percentage increase in cost greater than the percentage reduction in yield. This is because alternate control methods are taken away. (3) Production decreases will be less than the yield decrease, meaning that more land will be brought into the production. (4) Percentage increase in price will generally be larger than the percentage decrease in production; reflecting the elasticity of farm produces. This will raise the income of producers and decline the net income of consumers. (4) Reduced production and higher price of fruit and vegetable will lead to a reduction in the consumption. This will lead to a reduced intake of almost all vitamins and minerals.

Addition of valorem tax is an important tool to reduce pesticide use because it would be to effect voluntary reduction in pesticide use by increasing the private cost more nearly to the social cost (Shumway and Chesser, 1994). This increase in private cost will influence consumers to voluntarily purchase less harmful pesticide and appropriate technologies and also a more efficient application of the more environmentally harmful pesticide option (Pina and Forcada, 2004). The adoption of this measure by the Mexican government is because it is the most efficient way to prepare for compliance with future extension of the list of pesticide subjected to phase out and eliminated under international agreement (Pina and Forcada, 2004). Agne (2000) also state that, "the adoption of tax on pesticide is an effective way of reducing the demand for harmful pesticide". But Gerken (2001) explains that pesticide imported into Ghana have their tax been scraped from it, therefore the country is not enjoying the advantage of this strategy or measure.

Hussan *et al* (2001) explained that for alternative method in pest management for sustainable and profitable production in developing countries, IPM is an appropriate method which can reduce and minimize the use of pesticide as well as reducing the cost of production.

2.4. Integrated Pest Management (IPM) in Ghana

This section reviews literature on the history of integrated pest management in Ghana, organizations and institutions involved in integrated pest management in Ghana, international initiatives on integrated pest management in Ghana

2.4.1. History of IPM in Ghana

IPM has been recognized as one of the practical alternative measures that could be used to deal with many problems emanating from increasing pesticide use especially at the farm level.

However, the implementation had been restricted to few isolated crops in the developed and developing world. Recent developments, however, have shown that IPM could be more practical and field-oriented to the benefits of the ordinary farmer. Especially when it is adopted not as a technology, but as an approach and a strategy for developing technologies, to solving pest and disease problem as and when they occur (Kiss and Merman, 1991)

Until 1991, research on IPM in Ghana was fragmented and lacked a focus approach. Until then most of the research work was undertaken with the Council for Scientific and Industrial Research and the faculties of agriculture of the country's universities. These centered on the developing control measures, which were usually pesticide oriented, and screening germplasm for resistance to insect pest/ disease for the various crop commodities and well-planned experiments to study population dynamics and seasonal distribution of pest and their natural enemies, and the nature and influence of interacting biotic factors on pest populations, had been lacking. Furthermore, contacts with farmers had been very minimal (Nuamah, 2013).

Following the West African IPM workshop at the Accra Conference Center in Accra in the year 2013, Ghana, the National Plant Protection and Pesticide Regulatory Committee of the National Agricultural Research Project (NARP) submitted a memorandum to the NARP secretariat pushing adoption of IPM as a major component of Ghana's plant production/protection strategy. This recognized the excessive use of pesticides especially on crops like vegetable (tomato, cabbage) which had led to unacceptable residues in market produce resulting in risk to consumers and commodity rejection at the international market. Increasing incident of farmer poisoning and long-term effect of pesticide on aquatic and terrestrial ecosystems were further causing concerning to agriculturists and environmentalist (NARP, 1991).

The need to reduce dependence on chemical pesticides and the development and implementation of alternative pest control measures were therefore of urgent priority.

The NBCC, an IPM oriented institution, established a number of multidisciplinary crop-based working group, members of these groups included leading scientists engaged in agricultural research (from Ghanaian research institutions) technical officers and extensionists from the ministry of food and agriculture and importantly, local farmers. These groups worked to identify pest problems and recommended environmentally friendly and sustainable strategies for controlling the pest. And the grouped worked with crops and pest known to be associated with overuse and abuse of pesticide (NBCC, 1992).

After a global IPM meeting and study tour organized by the FAO inter-country IPM program August/September 1993 the Ghanaian government drafted a proposal for an FAO/Technical Cooperation program project to establish an IPM training of trainers' course in irrigated rice. The proposal was approved for the implementation at the Dawhenya Irrigated Rice Scheme from May to October 1995. The training had staff from Ministry of Food and Agriculture (MOFA), others from Burkina Faso and assistance from FAO Inter-country IPM Program in Asia and rice Master Trainer from Philippines National IPM program. Technical support were provided by the WARDA and local research institutions and the University of Ghana and also policy guidance and supervision were provide provided by the Oversight Committee chaired by the Director of Agricultural IPM Extension Services Directorate-MOFA (Nuamah *et al*, 2013, Davis, 1997).

The result of the training showed that the IPM/FFS was applicable in Africa and this observation was endorsed by the participant of an FAO Technical Consultation Workshop and Participatory

Training in IPM for Africa at Akosombo-Ghana. Subsequently, other follow-up training was established at other four irrigation site (i.e., Ashaiman, Afife, Botanga and Tono) in 1996. After the training of trainers and post training of trainer, over 80% of the farmers changed their practices and adopted the IPM strategies because yields increased from 3 t/ha to 6 t/ha and net returns increased 138% higher compared with reference group of farmer who had not been trained and worked according to convectional farmers' practice. This has led to a progressive application of the concept to Ghana's agriculture and to date, plantain, cassava, cowpea, sorghum and vegetable have received attention (Nuamah *et al*, 2013).

2.4.2. Organizations and Institutions involved in IPM in Ghana

Stakeholder involved in the promotion of IPM in Ghana to include farmers, extension agents of MOFA, researchers, NGOs and policy makers (Nuamah *et al*, 2013). Below is the role played by each stakeholder in IPM promotion.

Farmers

Farmer who have graduated from the training of trainer course are to form FFS groups with other farmer and discuss the problem they face on the farm with pest attacks and to teach the member who were not part of the training, how to curtail the problem. The result of the previous study program has convinced the government of Ghana that IPM/FFS has the potential to complement the extension delivery in the country.

Extension Agents

Similarly to the role of the farmer who has graduated from the training, the extension agents also are dissemination agent who carry the IPM known how received from the TOT to farmers select for training. They are also responsible for the supervision of farmers who are interested in implementing the disseminated IPM technology and finding out some problems farmers face in the implementation.

Researchers

In terms of researchers, the Ghana Agriculture Research Systems has been restructured with the establishment of the NARP which comprised all institutions engaged in agricultural research including the universities, research institutions under the CSIR, MoFA. Research is usually adaptive with farmer on farmer's field and also some basic research activities, especially in the universities. These research teams has some of the scientist concentrating on IPM issues, which is usually emphasize pest and disease identification and control with pesticide on calendar or "need-be" spraying schedules, cultural practices and use of resistant variety of crops.

NGO

Due to the validity of the IPM/FFS approach, MoFA institutionalized the Project Oversight Committee (POC) in May 1997 to facilitate the expansion of IPM/FFS in Ghana. The POC was chaired by Deputy Minister of MoFA and includes Directors of MoFA, the EPA. NGOs in Ghana have recently formed an action group and representative on the POC. The NGOs are expected to work closely with the National IPM Program. They are to be trained by the POC during the IPM/TOT and are expected to mobilize funds on their own to enable them train personnel to train farmer within their respective communities.

Policy Makers

The National Integrated Crop Protection Advisory Committee chaired by the deputy minister, MOFA was established by the government in April 1995. This advisory body on all IPM issues is made up of Policy makers to draft and endorse policies with respect to IPM, researcher, EPA, extension agent and farmer association

2.4.3. International Initiatives on IPM in Ghana

During the last two decades, there have been many scientific, policy and technological developments that have tremendous potential for implementing IPM throughout the world. Many national, regional and international initiatives have contributed significantly in the building capacity and favorable environment for IPM (Maredia *et al*, 2013)

These include, UN-FAO Plant Protection Service. Their role in the development and diffusion of IPM program has been well documented, example the IPM program implementation in Indonesia and also in Ghana known as the FAO inter-country IPM program in rice. Their latest development is been the establishment of the global IPM facility. This facility been established in the mid-1990s serves as a coordinating, consulting, advising and promoting entity for the advancement of IPM worldwide (www.fao.org/WAICENT/faoinfo/agrilt/agp/agpp/ipm).

USAID established the Collaborative Research Support Program (CRSP) on IPM and the program includes a consortium or several public and private institutions, NGOs and national programs. This is a research, education/training and information exchange collaborative partnership among the US and developing country institution (www.ag.vt.edu/ipmcrsp/) IPM Europe/IPM Forum is an initiative of the Natural Resources Institute in the UK which aims to help poor farmers in developing-countries by strengthening the capacity of NGOs to promote and implement appropriate IPM approach and techniques, as a component of sustainable agricultural development at the farm level (www.nri.org/IPMForum/index.htm)

The major constraint faced by the local institution and international initiatives in propelling the adoption of IPM in countries is because the FAO cooperate documents that in many developing countries have tended to strongly favor pesticide use through subsidies that distorted prices. Because of this, alternative pest control measures, even where successful technically, are often not financially competitive and farmers are reluctant to adopt them

2.5. Empirical literature on the adoption of IPM

This section discusses empirical literature on adoption of IPM practices by farmers from both developed and developing countries. These include the effects of relevant farmer characteristics on adoption of IPM practices such as age, gender, education, farming experience, and household size, income level. Farm characteristics such as farm size, level of expected benefit and institutional characteristics such as membership of farmer's based organizations, extension service.

2.5.1. Farmer characteristics

As already noted, the farmer characteristics to be discussed under this section include the effects of age, gender, education, farming experience, and household size, income levels on IPM adoption by farmers (Bonabana-Wabbi, 2002).

Age of the farmer

Studies in developing countries shows that age has a positive effect on the adoption of some IPM practices: Age was found to positively influence adoption of improved variety of sorghum in Burkina Faso (Adesiina and Baidu-Forson, 1995). In northern district of Bangladesh, age of respondent had a positive influence on the adoption of IPM (Hassan and Bakshi, 2005) and also in Iran age positively affected the adoption of IPM positively (Dinpanah, and Nezhadhosseini, 2013). On the opposite side, age is also found in literature to have a negative effect on the adoption of IPM in developing countries: in Uganda age of the farmer negatively influenced the adoption of IPM groundnut production technologies (Mugisha *et al*, 2004). Also the adoption of Hybrid Cocoa in Ghana was affected negatively by the increase in the age of the farmer (Boahene, Snijders and Folmer, 1999). Rasouli-Azar *et al*. (2008) found that there is a negative significant between age and IPM adoption.

In the developed country there is also a contention as to the effect of age of respondent on adoption. IPM adoption on peanuts in Georgia (McNamara, Wetzstein, and Douce, 1991), and chemical control of rice stink bug in Texas (Harper *et al*., 1990) has age of farmer having positive effect on adoption. The adoption of IPM sweep nets in Texas was positively affected by age of farmer (Harper *et al*., 1990).

From the literature it is noticed that in some countries aged farmers in the above countries are more likely to adopt IPM. This is because as the farmer grows older they become concern about their health and therefore will opt for a technology which is less harmful to their health but in other countries aged farmers are less likely to adopt IPM because of its labour intensive nature and high cost involved in hiring labour. This will make aged farmer adopt a less expensive technology in controlling pest (Beckmann, 1996).

Gender of Respondent

Gender issues in agricultural production and technology adoption have been investigated for a long time. Most show mixed evidence regarding the different roles men and women play in IPM adoption. Gender of the household head is hypothesized to influence the decision to adopt changes. The way gender influences adoption is location-specific.

In a developing country such as Ghana, it is seen that male in the central region are more likely to adopt Cocoa Disease And Pest Control (CODAPEC) and high tech cocoa (Baffoe-Asare *et al*, 2013). In Uganda gender had a positive coefficient indicating that males were more likely to adopt celosia than females. In groundnut production, males are more likely to adopt practicing close spacing (Bonabana-Wabbi, 2006).

Doss and Morris (2001) in their study on factors influencing improved maize technology adoption in Ghana, and Over field and Fleming (2001) studying coffee production in Papua New Guinea show insignificant effects of gender on adoption. The latter study notes "effort in improving women's working skills does not appear warranted as their technical efficiency is estimated to be equivalent to that of males". Since adoption of a practice is guided by the utility expected from it, the effort put into adopting it is reflective of this anticipated utility. It might then be expected that the relative roles women and men play in both 'effort' and 'adoption' are similar, hence suggesting that males and females adopt practices equally

Education of Respondent

Studies that have sought to establish the effect of education on adoption in most cases relate it to years of formal schooling (Tjornhom, 1995, Feder and Slade, 1984). Generally education is thought to create a favorable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices (Waller *et al*. 1998; Caswell *et al*., 2001). IPM is stated to be a complex technology (Pimentel, 1986; Boahene, Snijders and Folmer, 1999).

Education is thought to reduce the amount of complexity perceived in an IPM technology thereby increasing the technology's adoption. According to Ehler and Bottrell (2000), one of the hindrances to widespread adoption of IPM as an alternative method to chemical control is that it requires greater ecological understanding of the production system. For IPM, the relevance of education comes to play in a number of ways. First, effective IPM requires regular field monitoring of pests conditions to identify the critical periods for application of a pesticide or other control measures (Adipala *et al*, 1999). Farmers' knowledge of insect life cycles is also crucial when precision is required about the best stage of the life cycle to apply a particular control strategy. In addition, knowledge of the possible dangers from improper use of particular practices may direct farmers to the safest application procedure regarding a given control strategy especially where chemicals are involved. The ability to read and understand sophisticated information that may be contained in a technological package is an important aspect of adoption. In the case of IPM, the ability to comprehend pesticide application instructions and proper measurement required in certain control strategies becomes useful. Furthermore, distribution of knowledge reduces the risk of adopting a new technology. Increased education is thus expected to improve IPM adoption.

Studies reviewed, including Daku (2002) and Doss and Morris (2001), education positively affected IPM adoption. Results by Dinpanah and Nezhadhosseini (2013) in Iran shows that relation between education level and IPM adoption is positive. Research done by Shafiei (2007) , MCNamara *et al* (2008), Pezeshki Rad and Chizari (2008) confirmed that education has positive influence on IPM adoption. Rasouli-Azar *et al*., (2008) found that there is a positive and significant relationship between level of education and adoption. Using a tobit model Aubert (2013) showed that in turkey education has a positive effect on IPM adoption and small scale farmer.

Rogers (1983) also indicates that technology complexity has a negative effect on adoption. Using a Poisson regression Erbaugh *et al* (2010) found from their studies that education has a negative influence on the adoption of IPM. Studies by Mauceri (2005) shows that educational level of potato farmers in Carchi has a negative influence on IPM adoption.

Farming Experience

Experience is informal education. Variables relating to experience are found in many economic models, with mixed results. Lin (2001) finds experience to relate positively to the adoption of hybrid rice in China. Years of experience in IPM practice had negative influence on the adoption of the IPM technology in Nigeria (Ofuoku, 2009). Sharif-Zadeh *et al*., (2008) research showed that there is a positive significant relationship between the applications of integrated pest management by farmers with the variables experience of planting. Sharifi *et al*., (2007) also concluded that there is a positive significant relationship between applications of integrated pest management by farmers with experience in planting. Pezeshki-Rad *et al*., (2006) in their study showed that adoption of integrated management against stem cream rice eater with agricultural experience and experience of rice cultivation has a negative significant relationship.

Household size

Household size with member above eighteen year, as a proxy to labour availability may influence the adoption of a new technology positively as its availability reduces the labour constraints (Gbegehn and Akubuilo, 2013).

Household size had positive influence on the use of IPM, practices in Nigeria (Ofuoku *et al*, 2009). Results presented in by Baffoe-Asare *et al* (2013) shows a significant positive association between household size and adoption of IPM and Similar finding has been reported by Namwata *et al*. (2010) and Rajasekharan and Veeraputhran (2002).

Income Level

Farmers' wealth has been often associated with technology adoption because wealthy farmers, in Doss and Morris' opinion (2001, p. 35), can better bear risks which facilitates the adoption of new technologies. The work by Gillespie *et al*. (2007) also illustrates that the farmers' income level increased the likelihood of adoption of several best management practices. Samiee *et al*., (2009) in the research showed that there is a significant relationship between adoptions of integrated pest management with an annual farm income.

2.5.2. Farm Characteristics

The farm characteristics to be discussed under this section include the effects of farm size and level of expected benefit (Adesina and Baidu-Forson, 1995)

Farm Size

Farm size affects adoption costs, risk perceptions, human capital, credit constraints, labor requirements, tenure arrangements and more. With small farms, it has been argued that large fixed costs become a constraint to technology adoption (Abara and Singh, 1993) especially if the technology requires a substantial amount of initial set-up cost, so-called "lumpy technology." In relation to lumpy technology, Feder, Just and Zilberman, (1985) further noted that only larger farms will adopt these innovations.

In terms of IPM, Dörr and Grote (2009) demonstrate that farmers who are less likely to implement IPM practices hold biggest farms. The results of Maumbe (1999) suggest that the coefficient for the total area cultivated to cotton is positive and significant. This implies a scaleeffect in the use of IPM technology in Sanyati. Also if is identify that farm size as the most prominent variable explaining adoption decisions (Wozniak, 1984; Dorman, 1996). Farm size was significant in explaining, and positively correlated with, the adoption of organic systems of current production in Greece (Dimara and Skuras, 2003), improved wheat in Ethiopia (Negatu and Parikh, 1999), maize in Turkey (Boz and Akbay, 2005) and rice-wheat in Pakistan (Sheikh, Rehman, and Yates, 2003)

Burton *et al*. (2003) demonstrate the opposite effect. Coffee farmer in Arabia also are less inclined to adopt IPM technology when farm size increases (Isoto *et al*, 2013). Mc Namara *et al*. (1991) demonstrate the non-significance of the utilized agricultural area. From the above references it can be deduced that farmers with larger farmers are likely to adopt IPM than farmers with small land size.

Level of Expected Benefits

Programs that produce significant gains can motivate people to participate more fully in them. In fact, people do not participate unless they believe it is in their best interest to do so. Farmers must see an advantage or expect to obtain greater utility in adopting a technology. In addition, farmers must perceive that there is a problem that warrants an alternative action to be taken (Bonabana-Wabbi, 2002). Without a significant difference in outcomes between two options, and in the returns from alternative and conventional practices, it is less likely that farmers, especially small-scale farmers will adopt the new practice (Abara and Singh, 1993). Farmers may receive little long-term benefits from IPM adoption, which negatively influences adoption. A higher percentage of total household income coming from the farm through increased yield tends to correlate positively with adoption of new technologies (McNamara, Wetzstein, and Douce, 1991; Fernandez-Cornejo, 1996)

2.5.3. Institutional Characteristics

The various institutional factors that affect the adoption of technologies by farmers are discussed below. The factors discussed include membership of cooperatives, extension contacts.

Membership to Cooperatives

This variable is expected to have positive coefficient with adoption (Gbegehn and Akubuilo, 2013). This is because farmers who are members of cooperatives pull resources together for their individual benefits which give them the opportunity to adopt more technologies than others who are not members. Also, members of cooperatives get more information about improved agricultural management practices from their association than non-members of cooperatives.

Moreover, it links the individual to the larger society and exposes him to a variety of ideas. Members of cooperative societies are in a privileged position with respect to other farmers, in terms of their access to information on improved agricultural technologies. Being a member of a cooperative society is hypothesized to be positively associated with the adoption of improved agricultural technologies. Sharif-Zadeh *et al*., (2008) research showed that there is a positive significant relationship between the applications of integrated pest management by farmers with membership in cooperatives.

Extension Contacts

Good extension programs and contacts with producers are a key aspect in technology dissemination and adoption. A report by IFPRI (1998) stated that a new technology is only as good as the mechanism of its dissemination to farmers. Most studies analyzing this variable in the context of agricultural technology show its strong positive influence on adoption. In fact Yaron, Dinar and Voet, (1992) show that its influence can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies. Agricultural extension enhances the efficiency of making adoption decisions. Of the many sources of information available to farmers, agricultural extension is the most important for analyzing the adoption decision. Based on the innovation-diffusion literature (Adesina and Forson 1995), it is hypothesized that access to extension services is positively related to adoption of new technologies by exposing farmers to new information and technical skills.

Pattanayak *et al*. (2003) argue that access to extension services provided by the government, NGOs, and other stakeholders play a very important role in the adoption of new agricultural technologies. Farmers who are exposed to information about new technologies by extension agents (through training, group discussion, plots demonstration, and other form of information delivery) tend to adopt new technologies. An empirical study by Boughton *et al*. (2007) suggests that in Mali, the farm-level adoption rates for improved maize varieties could be significantly

CHAPTER THREE

METHODOLOGY OF THE STUDY

This chapter discusses the methodology of the study. This includes the conceptual framework and empirical specification, hypotheses of the study, data collection and sampling techniques, and data analysis.

3.1.0. Conceptual framework and empirical specification

In this study, adoption of IPM technologies is examined in a multivariate setting. Specifically, we consider adoption of pesticide application, pest monitoring and both pesticide application and pest monitoring. Each technology bundle is thought of as a possible adoption decision by the farmer: The farmer would then choose a bundle if it maximizes his expected utility. The expected utility of adoption of a particular technology bundle is represented by

$U(T_i, z)$

Where T_i denotes the i^{th} technology bundle and z is a vector of the exogenous variable.

Implicitly in the function are the profit, cost, and risk impacts of the adoption decisions as shown below.

$U(T, z)$

The choice of the farmer is can be shown as:

Choose $T_i: T_i = argmax[T, z], \quad i = 0,1, \dots s$

Where i=0 denotes non-adoption of the IPM technology. We follow the multinomial logit model to examine the decision of the farmers to adopt the three different IPM technologies bundle. This is in line with Byrne *et al*., (1991), who states that when, an individual's choice are discrete and consist of more than two alternatives, then a multinomial logit approach is appropriate.

The standard logit model for a single choice decision can be represented by two equations which are first, an unobservable variable described by a linear function of a set regression and normally distributed stochastic error. Secondly the equation describes the observable choice of the decision maker. Thus, the equations represented below:

$$U = z\beta + \varepsilon \tag{1}$$

$$y = 1, if\ U \geq 0 \qquad y = 0, otherwise \tag{2}$$

Where U is the unobservable variable (in the following application the U is the level of expected utility), z is a vector of the regressors which influence the level of the unobservable variable through the coefficient vector $\beta$and ε is the stochastic term.

But the multinomial logit model extends the unobservable variable in the first equation to a system of equations with unobservable dependent variable. The two equations can be written as:

$$U_i = z_i B_i + \varepsilon_i, \qquad i = 0,1, \dots, s \tag{3}$$

$$y_i = 1, if\ U_i = max\left[U_j, \qquad j = 0,1, \dots, s\right]; \quad y_i = 0, otherwise \tag{4}$$

Where y_i are the observed choice variable and z_i is the exogenous variables influencing the choice of the farmer. The stochastic terms are assumed to be jointly distributed multivariate normal random variables.

The probability of making a choice of adopting an IPM technology is given as:

$$Prob\ (Y_1 = j) = \frac{\exp(Z_i\beta_j^{'})}{\sum_{j=1}^{j}\exp(Z_i\beta_j^{'})} \quad (5)$$

Where, y_i is the observed outcome for the i^{th} individual with a vector of z_i. The estimated equations provide a set of probabilities for the $j + 1$ choices with characteristics z_i (Greene 2000). To remove indeterminacy in the model, the normalization procedure should be considered by taking $\beta_0 = 0$. Now, the probabilities would be as follows, as suggested by Greene (2000).

$$Prob\ (Y_i = j|x_i) = \frac{\exp(Z_i\beta_j')}{1+\sum_{j=1}^{j}\exp(Z_i\beta_j')} \qquad for\ j = 0,2,\ldots J,\ \beta_0 = 0 \quad (6)$$

Where $Pr\ (.)$ represents probability, j is one of J choices, and β are parameters to be estimated. Marginal effects for continuous variables are estimated at their mean values, while those for dummy variables are estimated as:

$$\Pr(Y_j = 1|\bar{x}_*, d = 1) - \Pr(Y_j = 1|\bar{x}_*, d = 0) \quad (7)$$

Where d is represents the dummy variable (Greene, 2000).

According Curtis *et al.*, (2003), the signs of the marginal effect are ambiguous making the signs of their marginal effects un-interpretable.

The multinomial logit model indicates the utility function of choosing to adopt neither of the technologies, pesticide application only, pest monitoring only or adopt both pesticide application and pest monitoring is represented as;

$$u_i = \beta_0 + \sum_{i=1}^{n} x_i\beta_i + v_i \quad (8)$$

Where u_i is the utility of adopting pesticide application only, pest monitoring only or adopt both pesticide application and pest monitoring. β's the parameter estimates, where $i = 1 \ldots \ldots j$. x_i are the exogenous explanatory variables. It includes Age, Family size, Educational level, Dependency ratio, FBO Training, Farm size, contract farming, income, perception of cost of labour, access to credit, Perception on the availability of hired labour, extension visit, distance from farm to pesticide sale point. Errors are assumed to be jointly distributed multivariate normal random variables. , $v_i \sim MVN(0, \varphi)$.

3.2.0. Hypotheses of the study

Based on the theoretical framework discussed above, the following hypotheses will be tested in the study:

1. Age, household size, educational level, income, access to credit, farm size, type of labour used and contract farming will positively influence the adoption of pest monitoring, pesticide application and adoption of both pest monitoring and pesticide application.
2. Dependency ratio and distance to farm will negatively influence the adoption of only pest monitoring, only pesticide application and adoption of both practices
3. Cost of labour will negatively influence the adoption of only pest monitoring, only pesticide application and adoption of both practices
4. Availability of labour will positively influence the adoption of only pest monitoring, only pesticide application and adoption of both practices
5. Extension visit will positively influence the adoption of only pest monitoring, only pesticide application and adoption of both practices.

3.3.0. Data Collection

This section discusses the method of data collection for the study. This includes the description of the study area, sampling technique, and survey instrument.

3.3.1. The Study Area

The study area is the Kumasi Metropolis of Ghana. Kumasi, located 300 kilometers Northwest of Accra is the second largest city in Ghana and well-known for the production and consumption of large amount of vegetables such as cabbage, spring onions and lettuce which are in increasing demand to satisfy the dietary needs of the ever-increasing population in the city (Drechsel *et al*, 2006; FAO, 2008). Increasing demand for fresh vegetables in urban areas has led farmers to intensify production by heavily relying on external inputs such as pesticide (Yeboah, 2013). For example, in Kumasi urban vegetable farmers can record as high as eight to eleven lettuce and spring onion harvests and alternating with three cabbage harvests, all in one year (Danso *et al*. 2002) just to meet the demand and in doing so apply great quantities of pesticide. Insight of this Kumasi proves to be good study area for IPM adoption since IPM technology aims to reduce the use of chemical pesticide in crop production.

The metropolitan area covers an area of 245 square kilometers. Kumasi has been the cross roads between the northern and the southern sectors of the country, since its establishment as the heart of the Ashanti Empire around the turn of the eighteenth century (Salifu, 1997). Generally, the Metropolitan area is located at more or less the central part of the Ashanti region (see fig 3.3). It lies within latitudes 6’38´ north and 6’45´ north and longitudes 10´41´05´´ west and 10 32´ west.

It is bounded on the north by the Kwabre District and on the South by Bosomtwe-Kwanwoma District. On the West and the East, Ejisu-Juaben District and the Atwima District bound KMA respectively. In relation to its fast physical and demographic growth as well as to the expansion of its role within the region, Kumasi is increasingly being considered as an entity extending beyond the administrative boundaries of the KMA to incorporate also the four neighbouring districts aforementioned. These five districts constitute the Greater Kumasi City Region (GKCR), to which, however, does not correspond any official administrative body (Corubolo and Mattingly, 1999).

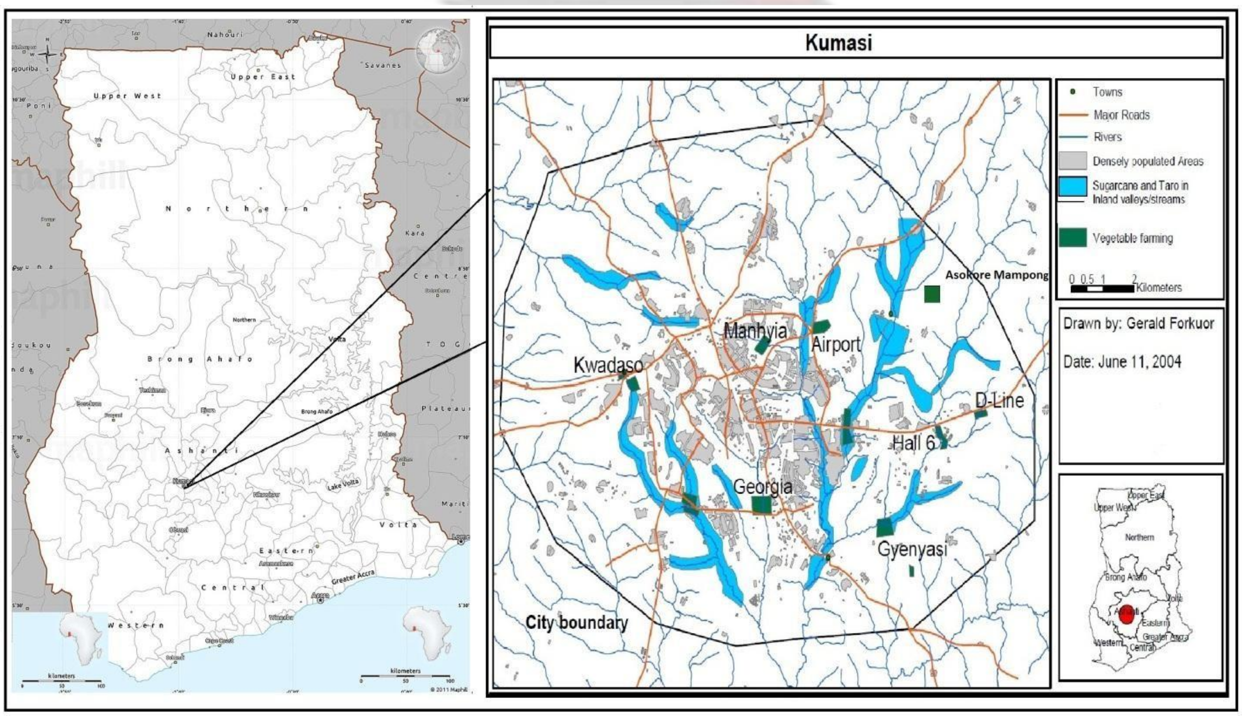
Kumasi metropolis is characterized by two main geological formations; namely the lower Birimian System of metamorphosed sediments of Pre- Cambrian origin, and the other, slightly later series of acid intrusive rocks. The latter consists of variably textural granitic rocks, which may be cut by pegmatites; whilst the former is made up predominantly of phyllitic schists, phyllites and metagreywackes (Gogo, 1990). Accordingly, Gogo found out that the granites, that may be cut by muscovite-rich or biotite-rich occur in large batholiths and as small masses that have usually intruded the lower Birimian sediments. The biotite-rich muscovite granites of Kumasi are foliated though not markedly in places. However, due to the variations in intensity of metamorphism in these granitic rocks, their texture and composition range from those of typical granites to granitic gneiss (Gogo, 1990). The geological formation of the metropolis has resulted to having rich soils in the metropolis for agricultural activities. The major soil type of the metropolis is the Forest Ochrosol. It is a very rich type of soil that has makes it possible for a lot of foodstuff.

The general topography of Kumasi metropolitan area is undulating with gentle slopes, commonly of 50 to 150. Kumasi itself lies on top of a local watershed at approximately 282 m high (NsiahGyabaah, 2000), but altitudes in the peri- urban interface around Kumasi vary from 250 to

300 meters (Holland *et al*, 1996). The granitic areas are slightly hilly and the interfluves ridges are flat topped with varying widths. The landform is an advanced dissection of a tertiary erosion surfaces (Holland *et al*, 1996). Kumasi lies within the moist semi- humid climatic zone of the country. It experiences two rainfall maxima annually with the annual mean rainfall of about 1345mm. The first rainy season is from mid-March to early July, and the Second season begins from late August to October. The mean annual temperature is about 28^0c with average monthly temperatures varying from 24^0c to 33^0c. Humidity varies from about 50 percent in the dry season to about 76 percent at the end of the main wet season. The vegetation of Kumasi has been characterized under the moist semi-deciduous forest zone of the country affirming the fact that it occurs within wet semi-equatorial climatic region (Dickson and Benneh, 1988). But due to rapid increases in population and the consequent urbanization, very little of the original forest remains. The rainfall pattern in the metropolis encourages the growth of vegetables and other food crops such as cabbage, lettuce, spring onion, plantain, cassava etc. This is because water forms an integral part in the production of such food crops and since the metropolis experience two rainfall seasons production of these crops can be done twice a year which is encouraging for a country which depends highly of rainfall as an irrigation mechanism for farming.

Agricultural land use in has been consigned to crop farming in the peri-urban communities (e.g. Dichemso, Takyiman, Parkoso, Apeadu, and Kokoben etc.) and along the banks and valleys of rivers/streams. Vegetables, both traditional and exotic, are more widely cultivated than traditional food crops. As it is the case, vegetable cultivation increases with greater urbanization of communities. The main locations for vegetable cultivation in Kumasi includes are Gyinyasi, KNUST, Manhyia, Kakaro, Georgia and Asokore Mampong. A vegetable produced in the Kumasi includes cabbage, carrot, spring onions, green pepper, lettuce, cucumber, French beans and tomatoes. In Kumasi 90% of lettuce contributed to the urban food supply in Kumasi is attained from the Kumasi metropolitan area whiles 10% is from the peri-urban area. 90% of spring onion contributed to the urban food supply in Kumasi is attained from the Kumasi metropolitan area whiles 10% is also from the peri-urban area and 60% of tomatoes are from the per-urban area of Kumasi (Drechsel *et al*, 2006).

Figure 1: vegetable producing site in Kumasi



Source: IWMI, 2004

3.3.2. Sampling Technique

The targeted population of the study was all tomato, cabbage and spring onion farmers in the Kumasi in Ashanti region of Ghana. For this study, individual vegetable farmers were taken as sampling unit. A multistage sampling procedure was adopted for the study. The first stage involved the purposive selection of the study area. Kumasi metropolis was selected for the studies. This area was chosen because its UA (urban agriculture) supplies large amount of vegetable such as tomato, cabbage, spring onions and lettuce which are in increasing demand to satisfy the dietary needs of the ever-increasing population of urban areas (FAO, 2008) . This area is also noted for intensive use of pesticides in vegetable production. With the help of the Agricultural Extension officers from the ministry of food and agriculture metropolis, the vegetable production areas in the study area was identified and was stratified into tomato, lettuce and cabbage producing area. From these areas, a purposive sample of selection of production areas was drawn from each stratum. This was on the criteria that selected production areas are areas selected for training by extension agents according MoFA, Kumasi, officials. From these identified production areas two production sites were randomly selected from these strata's. A total of six production site were selected for the sampling of individual farmer. The productions sites selected for the study included Gyinyase, Georgia Hotel, Weweso, D-line, Manhyia, and Asokore Mampong. Finally, a random sample of farmers was drawn after visiting the town and contacting producers. Total samples of 300 vegetable farmers were selected for the study. Equal sample size was not attained from each production areas because of uneven distribution of vegetable farmers in the selected sites.

3.3.3. Survey Instrument

Both secondary and primary data were collected for the study. The secondary data includes information on the study area, IPM technology, labour allocation, adoption of technology and information on how to analysis the data was attained from Ministry of Agriculture, Research Institutes and Research Station Reports in addition to Internet sources, books and previous studies or existing literature. This secondary information was used in write up of the study.

Both qualitative and quantitative primary data was collected using both close and open questionnaire. The questionnaire used in the study will cover 300 vegetable producing farmers. The primary data (variable) collected from farmer will be grouped into (a) Personal and household characteristics, (b) Pilot level and farm characteristics, (c) Awareness and perception of IPM practices, (d) adoption of IPM, (e) Labour allocation for IPM practices,(f) Constraint to IPM adoption and information attained from these group will be used in developing result for the study. Below is the structured questionnaire use to take data for the research.

3.4.0. Data Analysis

Both descriptive and empirical analysis were undertaken to achieve the study's specific objectives.

To capture the awareness of the vegetable farmers concerning the existence of the IPM technology as an alternative means of pest control than sole dependence on the use of chemical Pesticides, farmers were asked if they have through the media or extension agent have had any knowledge on pest control through the integration of cultural and chemical control based on a continuous pest monitoring. The response to the question was a "yes" or "no" and after the Statistical Software Programme for Social Sciences (SPSS) was used to compute the percentage of farmer aware of the existence of the IPM technology. To determine the perception of farmers on IPM, perception statements were attained through interviews with farmers before the data collection and literature. These statements were grouped into two categories thus "health perception" and income perception". Each perception response was measured on a three point

'Likert scale' with score of 1 for agree, 0 for undecided, -1 for disagree. The Statistical Software Programme for Social Sciences was also used in finding the mean score of each perception statement and the overall perception index for each category. This was done for tomato, cabbage and spring onion farmers separately.

To attain the specific IPM practices to be studied, literature was review and two core practices was selected which include pest monitoring and pesticide application. The adoption of these practices was treated as a discreet decision resulting in the choice variable being qualitative. All the possible combination of the practices to be adopted was included in the decision set. Four combinations was attained for the decision set which includes; (0) non-adoption of the two practices, (1) adoption of only pesticide application, (2) adoption of only pest monitoring and (3) adoption of both pesticide application and pest monitoring. In response farmers were to choose from the possible combination which one was used in the previous cultivation. In order to estimate a model with multiple discrete outcomes, the multinomial logit model was used. In the estimating the multinomial logit model using the Maximum Likelihood Estimate (MLE) the possible combination in the choice set used as the base of reference category is the non-adoption of the two practices. The main advantage of the multinomial logit is that it allows an analysis of multiple, unordered outcomes. The also multinomial logit estimates different coefficient for each outcome and it is not dependent on the independence of irrelevant alternatives (IIA).

To determine the cost and returns of adopters and non-adopters the gross margin analysis was used. Gross Margin (GM) is a useful planning tool in situations where fixed capital is negligible portion of the farming enterprises in the case of small scale subsistence agriculture (Olukosi and Erhabor, 1988). Gross margin of a firm is obtained by deducting the variable costs from the sales revenue and dividing by the income (Nix, 1998). Mathematically, a gross margin is defined

as:

$$GM = \frac{TR - VC}{TR} * 100$$

Where GM is the gross margin, TR is total revenue and VC is the variable cost incurred by the farmer. . Gross Margin reveals how much the farmer earns taking into consideration the costs that it incurs for producing the vegetables. This GM is computed for tomato, cabbage and spring onion farmers.

Kendall rank test was also conducted to assess the constraint of adoption of the IPM practices in vegetable production. Kendall's coefficient of concordance (W) is a measure of the agreement among several (p) judges who are assessing a given set of n objects. In this study, the judges were the vegetable farmers assessing the various perceived reasons for using or not using the IPM practices in controlling pest. The W statistic was obtained from the formulas below

$$W = \frac{12S}{p^2(n^3 - n) - pT}$$

Where n is the number of objects, p the number of judges. T is a correction factor for tied ranks (Siegel 1956, p. 234). It was estimated with the aid of the non-parametric test of K-related sample which gave the various mean rank values attached to the perceived reasons. It also provided the Kendall's W, which is their agreement level and the associated p-value. The significance of the P-value indicates that the judges are in concordance or agreement

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter discusses the result of the study. The results and discussion is sectioned into two. The first section discusses the descriptive results, which include personal and household characteristic of the farmers, farm characteristics, gross margin analysis, farmer awareness, adoption and constraints to adoption of IPM practices. The second section discusses the empirical results.

4.1. Descriptive results

4.1.1. Personal and Household Characteristics

The personal and household characteristic considered include gender, age, marital status, ethnic group, educational level, household size, dependency ratio, membership to a farmer based organization, access to credit, source of credit, amount of credit attained, occupation, income and these through literature has been considered to affect the adoption of IPM practices. Table 2 is a table representing the distribution of the personal and household characteristics of the farmer.

Table 4.1: Personal and Household Characteristics of Adopters and Non-adopters of IPM Practices

Characteristic	Full Sample N= 300(100)	Adopters N=247(82.3)	Non-adopters N=53(17.7)
Age	49.77[a]	52.21[a]	47.33[a]
Gender			
Male	261(87)	232(93.9)	29(54.7)
Female	39(13)	15(6.1)	24(45.3)
Marital status Single			
	13(4.3)	10(4.0)	3(5.7)
Married	287(95.7)	237(96.0)	50(94.3)
Ethnic group			
Akan	218(72.7)	190(76.9)	28(52.8)
Ga	6(2)	4(1.6)	2(3.8)
Ewe	15(5)	11(4.5)	4(7.5)
Northern ethnicity	61(20.3)	42(17)	19(35.8)
Education None			
	69(23)	40(16.2)	29(54.7)

1 year-9 years (J.H.S)	75(25)	69(27.9)	6(11.3)
10 years-12years (S.H.S)	34(11.3)	30(12.1)	4(7.5)
13 years-15 years (Diploma)	86(28.6)	78(31.6)	8(15.1)
Greater than 15years (Degree)	36(12)	30(12.2)	6(11.3)
Household size	6.58[a]	6.30[a]	11.9[a]
Dependency ratio	0.50[a]	0.48[a]	0.52[a]
Income	1498.7[a]	1977.2[a]	1020.2[a]
Membership to FBO			
Yes	264(88.0)	228(92.3)	36(67.9)
No	36(12.0)	19(7.7)	17(32.1)
Access to credit			
Yes	291(97)	247(100)	44(83.0)
No	9(3)	0	9(17)
Source of credit Family and friends	40(13.7)	37(15)	3(5.7)
Personal saving(bank)	161(55.3)	134(54.3)	36(67.9)
Money lender	60(20.6)	49(19.8)	11(20.7)
Donor organization	30(10.3)	27(10.9)	3(5.7)
Amount of credit attained	1266.2[a]	1550.2[a]	982.2[a]
Occupation Only farming	122(40.7)	112(45.3)	10(18.9)
Farming and other	178(59.3)	135(54.7)	43(81.1)

Note: figures in parenthesis are percentages
[a] indicates mean of the variable
Source: Field survey, 2012

The mean age of the vegetable farmers in the study area is 49.77. Comparatively, the age of farmer adopting either or both of the IPM practices was higher (52.21) than that of non-adopters of the practices (47.33). It is also noticed that males dominated in vegetable production in the study are with a percentage of 87 and it is consistent with the finding of Nonga *et al*. (2011). Also high percentage of male (93.9%) adopted either or both of the IPM practices than nonadopters but vice versa for the female vegetable farmers. About 76.9% of the farmers attained formal education. About 16.2% of farmers who have adopted either of both of the IPM practices have not attained formal education but and 54.7% of non-adopters have not have not attained formal education. A higher percentage (83.8%) of farmers adopting either or both practice spent 10 to15 years in formal education. The mean household size of the farmers is 6.58. The result is consistent with the research of Cornish *et al* (2001). The non-adopters of either of both of the IPM practices had a higher mean household size (11.9) than the adopters. It is also seen that adopters of either or both IPM practice received a high income (mean income = 1977.2) than non-adopters (mean income = 1020.2). About 92.3% of farmers in the study area who adopted either or both of the IPM practices where members to an FBO but 7.7% of the vegetable farmers are not members of any FBO and have adopted the IPM practices. A higher percentage (100%) of farmers adopting either or both of the IPM practices have access to credit and also 83.0% of non-adopters did have access to credit adopted the IPM practices. This result is consistent with the work of Nwalieji (2008). Majority of the farmers (45%) who were into farming and other occupation adopted either of both of the IPM practices looked into.

4.1.2. Farm Characteristics

This section looks at the farm level characteristics and it takes into consideration n farm size, distance to farm, type of soil, slope of the land, type of crop grow, irrigation, source of irrigation water, use of waste water and visit by agricultural extension agent. Below is a table showing the distribution of the stated characteristics.

Table 4.2: Farm Level Characteristics of Adopters and Non-adopters of IPM Practices

Characteristics	Full sample N=300(100)	Adopters N=247(82.3)	Non-adopters N=53(17.7)
Farm size (hectare)	0.54[a]	0.49[a]	0.60[a]
Soil type			
loamy soil	282 (94.0)	231(93.5)	51(96.2)
Others	18 (6.0)	16(6.5)	2(3.8)
Slope of land			

Gentle slope	88(29.3)	65(26.3)	23(43.4)
Steep slope	2(0.7)	2(0.8)	0(0.0)
Flat grounds	210(70.0)	180(72.9)	30(56.6)
Crop produced			
Spring onions production	33(11.0)	26(10.5)	7(13.2)
Cabbage production	112(37.3)	85(34.4)	27(50.9)
Tomatoes production	155(51.6)	136(55.1)	19(35.8)
Contract farming			
Yes	55(13.3)	37(15.0)	18(34)
No	245(81.7)	210(85.0)	35(66.0)
Irrigation			
Manual	278(96.3)	242(98.0)	36(68.0)
Mechanized	22(7.3)	5(2.0)	17(32.0)
Source of irrigation water			
River	255(85.0)	233(94.3)	22(41.5)
Dugout wells	45(15)	14(5.7)	31(58.5)
Tap water	0(0.0)	0(0.0)	0(0.0)
Waste water usage			
Yes	11(3.7)	4(1.6)	8(15.1)
No	289(96.3)	243(98.3)	45(84.9)
Visit from AEA			
Yes	217(72.3)	207(83.8)	10(18.9)
No	83(27.6)	40(16.2)	43(81.1)
Distance traveled to pesticide sale point	6.42[a]	4.83[a]	8.01[a]
Type of labour employed			
Family labour only	36(12.0)	26(10.5)	10(18.9)
Hired labour only	166(55.0)	146(59.1)	20(37.7)
Both hired and family labour	98(33.0)	75(30.4)	23(43.4)
Labour hours allocated per week			
1-39 hours	244(81.0)	204(82.6)	40(75.5)
>40 hours	56(19.0)	43(17.4)	13(24.5)

Note: figures in parenthesis are percentages
[a] indicates mean of the variable Source: Field survey, 2012

The mean farm size farmers engaged in vegetable production in the study area is 0.54 hectare and this tarries with the result of the study by Ngeleza (2011). Non-adopters of either or both of the IPM practices employed a larger farm size (mean of 0.60 hectare) than that of the area of land employed by the adopters. Majority of the sampled vegetable farmers (51.6%) cultivated tomato. The highest percentage of vegetable farmers adopting either or both of the IPM practices were tomato farmers (55.1%) followed by cabbage farmers (34.4%). About13.3% of the vegetable farmers produced on contract basis and 81.7% of the farmers did not. 85.0% of adopter of either or both of the IPM practices di not produce on contract basis and 15.0% of adopter of the IPM practices produced on contract basis. It is noticed that 72.3% of the farmers had visitation from extension agent. About 83.8% of the farmers adopting either or both of the IPM practices had visits from extension agents and are. Also 16.2% of farmers who have adopted either or both of the IPM practices did not have any visit from extension agents. The average distance traveled by the farmer to a pesticide sales point is 6.42 kilometers. Adopters of either or both of the IPM travel a shorter distance (4.83 kilometers) to pesticide sale point than that of non-adopters. Majority of the farmers (55%) employed hired labour only on their farms. About 33% employed only family labour only and 12% employed both family and hired labour. About 59.1% of farmers who have adopted either or both of the IPM practices employs hired labour only on the farm. 10.5% of the adopters of the IPM practices employed family labour only and

30.4% of the adopters employed both family and hired labour. About 81% of the farmers are part-time farmers. 82.6% of the adopters were part-time farmers and 17.4% of the adopters of either or both of the IPM practices were full-time farmer.

4.1.3. Adoption of IPM practices by vegetable farmers

Farmer awareness is an important tool for the adoption of an available technology. Therefore looking into the awareness of farmers concerning the IPM practices it shows that 289 (96.3%) of the respondent were informed of the existence of the practices looked into and their application in the control of pest. This indicates a broad level of awareness in the vegetable farming community and this is made possible by the created awareness on IPM by Non-Governmental Organizations (NGO) in advocating for Integrated Pest Management (IPM) (Keraita *et al.*, 2008).

About 33.9% of the respondents were made aware of these practices through the media (television) and 50.5% through friends. Ministry of food and agriculture contributed to making 12.1% of farmers aware of the IPM practices and farmer based organization also contributed to making 3.6% of the farmer aware.

Upon being aware of the existence of IPM, the table below shows how much farmers have adopted the selected IPM practices. The IPM practices being looked into were selected because literature proves that they are the core practices in the IPM technology.

Table 4.3: Distribution of IPM adoption

IPM Practices	Adopters	Non-Adopters
Pest monitoring only	64 (21.12)	236(78.88)
Pesticide application only	168(56)	132(44)
Adoption of both pest monitoring and pesticide application	35 (11.55)	265(88.45)

The figures in parentheses are percentages
Source: field survey (2012)

From the above table 21.12% of farmers adopted the use of only pest monitoring only without pesticide application; which implies that about 21% of farmers in the study area are into organic farming. 56% of farmers also adopted the use only pesticide application to control pest. This implies that about 49% of the farmers are still in the adoption of the farmer's best practice. From the studies 11.55% of the farmers adopted both pest monitoring and pesticide application. 70.29% of the farmers adopted only one of the practices enlisted and this indicates that level of adoption of at least one of the two practices is relatively high.

4.1.4. Perception of Vegetable Farmers on IPM Adoption

After the adoption further examine the perception of farmer on IPM practices. This was carried out by asking farmer to tick from the options whether they agree, undecided, disagree about that the perception statement. Below are the tables showing the distribution of the responds.

From the table below, the mean perception for tomato, cabbage and spring onion farmers on the statement "IPM improves the quality of vegetables" is found to be 0.8, 0.4 and 0.6 respectively showing that tomato and spring onion farmers are in agreement with the perception statement but cabbage farmers are not in agreement with the statement. Also the mean perception for tomato, cabbage and spring onion farmers on the statement that the practice of IPM reduces health problem is found to be 0.9, 0.5, and 0.3 respectively. This is shows that tomato and cabbage farmers agree with the statement but spring onion farmers do not agree with the statement. It is seen that cabbage and spring onion farmer agree to the fact that IPM reduces environmental pollution (mean perception = 0.6 and 0.5 respectively) but tomato farmers disagree with the statement (mean perception = 0.3). The health perception index of the statement was found to be 0.6, 0.5, and 0.5 which shows that the tomato, cabbage and spring onion farmers in the study area generally are in agreement with the health perception statement.

Also the mean perception for tomato, cabbage and spring onion farmers on the statement "IPM increases the price of the vegetable" is found to be 0.2, 0.0 and 0.4 respectively showing that tomato and spring onion farmers are in disagreement with the perception statement but cabbage farmers are undecided about the statement. Also the mean perceptions (0.6, 0.6 and 0.8) shows that tomato and cabbage spring onion farmers agree that the practice of IPM increase income. It is seen that tomato and spring onion farmers agree to the fact that IPM increases yield (mean perception = 0.9 and 0.6 respectively) but cabbage farmers disagree with the statement (mean perception = 0.1). The income perception index of the statement was found to be 0.6, 0.2, and 0.6 which shows that the tomato and spring onion farmers in the study area generally are in agreement with the health perception statement but spring onion farmers disagree with statement.

Table 4.4: Perception of farmers about IPM adoption

Statement	lettuce farmers				Cabbage farmers				Spring onion farmers			
	Agree	Undecided	Disagree	Mean score	Agree	Undecided	Disagree	Mean score	Agree	Undecided	Disagree	Mean score
Health perceptions												
IPM improve vegetable quality	135 (87.1)	6 (3.9)	14 (9.0)	0.8	74 (66.1)	8 (7.1)	30 (2.7)	0.4	24 (72.7)	4 (12.1)	5 (15.2)	0.6
IPM reduce human health problem	150 (96.8)	1 (0.6)	4 (2.5)	0.9	80 (71.4)	5 (4.4)	27 (24.1)	0.5	20 (60.6)	3 (9.1)	10 (30.3)	0.3
IPM reduces environmental pollution	100 (64.5)	10 (6.4)	45 (29.0)	0.3	85 (75.9)	7 (6.3)	20 (17.9)	0.6	25 (75.8)	0 (0.0)	8 (24.2)	0.5
Health perception index				0.6				0.5				0.5
Income perceptions												
IPM increases the price of vegetable	85 (54.8)	20 (12.9)	50 (32.3)	0.2	50 (44.6)	12 (17.9)	50 (44.6)	0	20 (60.6)	5 (15.2)	8 (24.2)	0.4
IPM increases income	125 (80.6)	0 (0.0)	30 (19.4)	0.6	87 (77.7)	10 (8.9)	15 (13.4)	0.6	27 (81.8)	6 (18.2)	0 (0.0)	0.8
IPM increases yield	145 (93.5)	5 (3.2)	5 (3.2)	0.9	55 (49.1)	17 (15.2)	40 (35.7)	0.1	25 (75.8)	4 (12.1)	4 (12.1)	0.6
Income perception index				0.6				0.2				0.6

Rating: (Mean score ≥ 0.5 = Agreed, 0 = undecided, Mean score < 0.5 = Disagreed)

Note: Percentages are in parentheses

Source: Field survey 2012

4.2. Empirical Result

This section looks at the how the variables influence the adoption of the various IPM practices. This takes into consideration the definition of the variables, the difference in mean between adopters and non-adopters of pesticide application only, pest monitoring only and both pesticide application and pest monitoring, and multinomial logit model estimation on the adoption of the IPM practices. Below is a table showing the definition of variable used in the empirical model.

Table 4.5: definition of variables used in the empirical model

Variable	Definition	Mean	Sd
Personal and Household Characteristics			
AGE	age of farmer in years	49	8.96
HHSIZE	household size	6.58	2.51
DPRATIO	ratio of dependent (under 16 +above 65)to the working age (16-65 years) in the family	0.50	0.44
EDU	Number of years of formal education	5.20	5.38
INCOME	Average monthly income (GH₵)	GH₵ 813.83	702.78
ACREDIT	1 if farmer has access to credit, 0 otherwise	0.57	0.49
FBO	1 if farmer received FBO training, 0 otherwise	0.21	0.14
Farm Characteristics			
FSIZE	area of land under vegetable cultivation (in Ha)	1.35	0.93
CFARM	if farmer is practicing contract farming	0.50	0.50
DISTPEST	Distance from farm to pesticide sales center (Km)	3.99	4.35
LABHOURS	1 if full time labour hours, 0 otherwise	0.55	0.49
HLAB	1 if farmer employed hired labour, 0 otherwise	0.55	0.49
Institutional Characteristics			
PLABCOST	1 if farmer perceives labor costs as high, 0 otherwise	0.50	0.50
AVAILLAB	1 if labor is readily available, 0 otherwise	0.75	0.43
EXTVISIT	Number of extension visit in a month	3.29	3.11

Field Survey 2012.

From the above the mean age of the farmer was 49.77 with a standard deviation of 5.50. It was noticed that the mean number of people in the farmers household was 6.58 with a standard deviation of 2.51 and these household had a mean dependence ratio of 50%. The mean school completion index of farmers was 1.81 implying that farmers have their years of formal education ranging in between 1-12 years. Farmer's membership to any farmer base organization had a mean of 0.21 with a standard deviation of 0.14. The mean hectare of land under vegetable cultivation was 1.35ha. Farming on contract basis had a mean of 0.50. Access to credit had a mean of 0.97 with a standard deviation of 0.17. The mean of farmer who employ only family labour is 0.55. The mean of farmer with the perception of high cost of labour is 0.48. The mean of farmer with the perception that labour is available was 0.75. The mean distance travel by farmer from farm to pesticide sale point is 3.99 and visit from extension officers to farmers had a mean of 0.57.

Further, the difference in mean between adopters and non-adopters of pesticide application only, pest monitoring only and both pesticide application and pest monitoring was computed. The table below summarizes the difference of the means.

Table 4.6a: Descriptive Statistics of Adopters and Non-adopters of Pesticide Application

Variable	Adopters N=149(49.2)		Non Adopters N=151(50.8)		Difference in Mean	T Value [Pr(|T|>|T|)]	
	MEAN	Sd	MEAN	Sd			
AGE	48.81	8.06	48.66	9.20	0.16	0.12	(0.90)
HHSIZE	6.44	2.27	6.63	2.58	-0.19	-0.53	(0.59)
DPRATIO	.4902	.41245	.5079	.45963	-0.02	-0.89	(0.37)
EDU	1.97	1.52	1.78	1.34	0.19	0.99	(0.32)
INCOME	823.44	762.51	811.23	687.40	12.21	0.12	(0.90)
ACREDIT	0.95	0.21	0.97	0.16	-0.02	-0.89	(0.37)
FBO	0.33	0.47	0.18	0.39	0.15	2.54***	(0.01)
FSIZE	1.29	0.80	1.36	0.95	-0.06	-0.47	(0.64)
CFARM	0.56	0.50	0.49	0.501	0.08	1.07	(0.29)
HLAB	0.44	0.50	0.58	0.49	-0.15	-2.11**	(0.03)
LABHOURS	0.50	0.35	0.64	0.34	-0.14	0.09*	(0.02)
DISTPEST	3.09	3.22	4.24	4.60	-1.14	-1.87*	(0.06)
PLABCOST	0.58	0.50	0.45	0.50	0.12	1.78*	(0.08)
AVAILLAB	0.80	0.41	0.74	0.44	0.06	0.90**	(0.05)
EXTVISIT	3.67	3.473	0.55	0.50	0.13	1.80*	(0.07)

Note: ***,**, * denote significance at 1%, 5% and 10% respectively

Source: Field survey 2012

From the table above, it is noticed that there is a 1% significance difference in the means of farmers who adopt pesticide application only and non-adopters of pesticide only in terms of whether or not a farmer receives training from any farmer based organization. Also there is a 5% significance difference in the means of farmers who adopt pesticide application only and nonadopters of pesticide application only in terms of whether or not a farmer employs only hired labour and also as to whether or not farmers spend full time on farm. For farmers perception on the cost of labour (where high or low), it was found that there was a significant different (1%) in terms of how the adopter of pesticide application only and non-adopter of pesticide only perceive the cost of labour. There is also a significant difference in how adopter and non-adopter of pesticide application only view the availability of hired labour. The mean distance traveled by farmer who adopted only pesticide application and farmers who a non-adopter is significantly different. The difference in mean in terms of extension visit received by farmers is also significantly different.

Table 4.6b: Descriptive Statistics of Adopters and Non-adopters of both Pest Monitoring

Variable	Adopters N=64(21.1)		Non Adopters 236(78.9)		Difference In Mean	T Value [Pr(|T|>|T|)]
	Mean	Sd	Mean	Sd		
AGE	49.30	9.13	47.92	8.71	1.38	1.33 (0.19)
HHSIZE	6.60	2.45	6.58	2.61	0.02	0.07 (0.95)
DPRATIO	.4547	.45	0.57	0.44	-0.11	-2.16** (0.03)
EDU	1.77	1.31	1.87	1.47	-0.10	-0.61 (0.55)
INCOME	813.99	678.72	813.64	734.90	0.35	0.004 (0.99)
ACREDIT	1.00	0.00	0.93	0.25	0.07	3.49*** (0.00)
FBO	.12	0.33	0.33	0.47	-0.20	-4.33***(0.00)
FSIZE	1.41	0.98	1.25	0.83	0.16	1.52 (0.13)
CFARM	0.50	0.50	0.51	0.50	-0.01	-0.13 (0.90)
HLAB	0.66	0.48	0.42	0.50	0.24	4.34*** (0.00)
LABHOURS	0.50	0.50	0.59	0.47	0.09	0.18 (0.11)
DISTPEST	4.46	4.89	3.40	3.50	1.05	2.09** (0.04)
PLABCOST	0.4524	0.50	0.52	0.50	-0.06	-1.08 (0.28)
AVAILLAB	0.80	0.40	0.69	0.47	0.11	2.29** (0.02)
EXTVISIT	2.60	3.49	0.55	0.50	0.05	0.86 (0.39)

Note: ***,**, * denote significance at 1%, 5% and 10% respectively
Source: Field survey, 2012

From table 4.6b, the mean dependency ratio of adopter of pest monitoring and non-adopters of pest monitoring is significantly different at 5% significant level. It is noticed that there is a 1% significance difference in the means of farmers who adopt pest monitoring only and non-adopters of pest monitoring only in terms of whether or not a farmer receives training from any farmer based organization. It is also found that, the mean number of farmer who have access to credit and have adopted pest monitoring only differs significantly from the mean of farmer who have access to credit and have not adopted pest monitoring. Also there is a 1% significance difference in the means of farmers who adopt pest monitoring only and non-adopters of pest monitoring only in terms of whether or not a farmer employs only hired labour. There is a significant difference in how adopter and non-adopter of pest monitoring only view the availability of hired labour.

Table 4.6c: Descriptive Statistics of Adopters and Non-adopters of both Pest Monitoring and Pesticide Application.

Variable	Adopters N=35(11.6%)		Non Adopters N=265(88.5%)		Difference in Mean	T Value [Pr(|T|>|T|)]
	Mean	Sd	Mean	Sd		
AGE	50.37	7.62	48.46	9.14	1.91	1.18 (0.24)
HHSIZE	7.23	2.72	6.49	2.47	0.73	1.63* (0.10)
DPRATIO	0.70	0.42	0.48	0.45	0.22	2.74 (2.74)
EDU	1.71	1.56	1.83	1.36	-0.12	-0.46 (0.65)
INCOME	717.14	699.36	828.33	705.96	-111.18	-0.88 (0.38)
ACREDIT	0.91	0.28	0.98	0.15	-0.06	-2.05** (0.04)
FBO	0.46	0.51	0.18	0.39	0.26	3.79*** (0.00)
FSIZE	1.10	0.75	1.37	0.93	-0.27	-1.64* (0.10)
CFARM	0.66	0.48	0.48	0.50	0.18	1.99** (0.05)
HLAB	0.54	0.51	0.56	0.50	-0.01	-0.14 (0.89)
LABHOURS	0.43	0.52	0.16	0.32	0.31	0.31** (0.03)
DISTPEST	2.09	1.12	4.19	4.47	-2.10	-2.77***(0.01)
PLABCOST	0.46	0.51	0.48	0.50	-0.02	-0.24 (0.81)
AVAILLAB	0.77	0.43	0.75	0.43	0.02	0.24 (0.81)
EXTVISIT	3.29	3.11	0.61	0.49	-0.32	-3.69***(0.00)

Note: ***,**, * denote significance at 1%, 5% and 10% respectively
Source: Field survey 2012

From table 4.6c, the mean household size of adopter of both practice (pesticide application and pest monitoring) and non-adopters of both practices is significantly different at 10% significant level. The mean number of farmers who are farming on contract basis and have adopted both practices differs significantly from the mean of farmers who have not adopted both practices. It is noticed that there is a 1% significance difference in the means of farmers who adopt both practice and non-adopters both practice in terms of whether or not a farmer receives training from any farmer based organization. It is also found that, the mean number of farmer who have access to credit and spends full time on farm and have adopted both practice only differs significantly from the mean of farmer who have access to credit and have not adopted both practice. Also there is a 1% significance difference in the means of farmers who adopt both practices and non-adopters of both practices in terms of whether or not a farmer employs only hired labour. There is a significant difference in how adopter and non-adopter of pest monitoring only view the availability of hired labour. The mean number of farmers who have extension visits and have adopted both practices differs significantly from the mean number of farmers who do not receive extension visit and have not adopted both practices.

To find the influence of the variables on the adoption of these practices, the multinomial logit was used. The multinomial logit was suggested by Dorfman (1996) as an effective model. In the estimation variables which includes; age, household size, dependence Ratio, Education level, FBO training, farm Size, contract farming, access to credit, income, employment of hired labour, time spent on farm, perception on labour cost, availability of labour, distance from home to point of sales of pesticide, extension visit. Below is the result of the multinomial logit estimate on the adoption of the IPM practices:

Table 4.7: Multinomial logit estimates on adoption of IPM practices

Variable	Pesticide application only		Pest monitoring 0nly		Both pest monitoring and pesticide	
	Coefficient	Marginal effect	coefficient	Marginal effect	Coefficient	Marginal effect
AGE	0.0898***	0.0055	0.0716**	-0.0011	0.0589	-0.0006
	(2.73)	(1.33)	(2.28)	(0.26)	(1.49)	(0.49)
HHSIZE	-0.2596**	-0.0283*	-0.1666	0.0064	0.0828	0.0132*
	(2.03)	(1.80)	(1.38)	(0.38)	(0.56)	(1.60)
DPRATIO	-0.5403	-0.0476	-0.4401	-0.0258	0.6543	0.0540
	(1.01)	(0.79)	(0.86)	(0.35)	(1.09)	(1.54)
EDUC	0.0699*	0.0085	0.0300	-0.0096*	0.1118***	0.0034
	(1.78)	(1.61)	(0.81)	(1.71)	(2.38)	(1.41)
FBO	1.0000*	0.2529***	-0.1164	-0.2997***	1.1899**	0.0631
	(1.73)	(3.07)	(0.21)	(3.67)	(1.89)	(1.45)
FSIZE	0.7961**	0.0475	0.5973*	-0.0386	1.1305***	0.0250
	(2.32)	(1.02)	(1.87)	(0.79)	(2.51)	(1.59)
CFARM	1.4141***	0.0543	1.1783***	-0.0459	2.3770***	0.0628*
	(2.96)	(0.91)	(2.59)	(0.70)	(4.14)	(1.81)
HLAB	0.8124*	-0.1407**	1.5919***	0.2345***	0.8567*	-0.0178
	(1.76)	(2.28)	(3.68)	(3.67)	(1.59)	(0.83)
AVAILLAB	1.3622***	0.0224	1.4688***	0.1133	1.0286**	-0.0134
	(3.23)	(0.33)	(3.83)	(1.50)	(2.04)	(0.56)
DISTPEST	-0.2453***	-0.0217*	-0.1391**	0.0276**	-0.4763***	-0.0153***
	(3.38)	(1.81)	(2.43)	(2.23)	(2.39)	(2.50)
ACCREDIT	0.5448	0.1353**	0.1082	0.0051	-1.5703***	-0.1258**
	(1.15)	(2.20)	(0.24)	(0.07)	(2.81)	(2.19)
PLABCOST	1.1953***	0.1003*	0.8315**	-0.0428	0.7030	-0.0090
	(2.93)	(1.72)	(2.24)	(0.69)	(1.43)	(0.52)
LABHOURS	-0.5733	-0.0368	-0.4863	-0.0135	0.0971	0.0277
	(1.48)	(0.64)	(1.34)	(0.23)	(0.21)	(1.26)
EXTVISIT	0.3450***	0.0033	0.3450***	0.0063	0.4760***	0.0075
	(2.69)	(0.21)	(2.85)	(0.38)	(3.27)	(1.26)

CONS	-5.1877*** (3.52)	-3.6658*** (2.66)	-5.9643*** (3.28)
Observations	168	64	35
Log Likelihood	-250.20		
Wald Chi2 (45)	104.71***		

Note: ***,**, * denote significance at 1%, 5% and 10% respectively
Z values are given in parentheses Source: Field Survey, 2012.

The results from fitting the multinomial logit model of adoption to 300 observations are reported in table above. The outcome refers to the adoption of pesticide application only, of pest monitoring only, and of both Pesticide application and pest monitoring. The coefficients reported in these columns are the beta estimate of the variable in favor of adopting a particular technology indicated at the top of the column, relative to adopting neither technology.

From the above table, farmer's age has a positive and significantly (1%) different from zero effect on the adoption of pesticide application only relative to the adoption of neither of the practices. One unit increase in age of the farmer increases the relative odd ratio that the farmer will adopt pesticide application relative to adopting neither IPM practice by 0.0898. Also farmer’s age was significantly positive in terms of the adoption of pest monitoring relative to the adoption of neither on the practices, thus a unit increase in the age of the farmer will increase the relative odd ratio of adopting pest monitoring relative to adopting neither practices by 0.0716. The relative odd ratio of adopting of both practices relative to adopting neither was also found to be 0.05 and this effect was also positive but not significant. This shows that the aged farmers are inclined to adopt the various IPM practice bundle except the adoption of both practices. From the above table, the marginal effect of age on the adoption of the various bundles of practices was not significant at any level. The positive effect is thought to stem from accumulated knowledge and experience of farming systems obtained from years of observation and experimenting with various technologies. In addition, since adoption pay-offs occur over a long period of time, while costs occur in the earlier phases, age (time) of the farmer can have a profound effect on technology adoption. This result is consistent with the work of Hassan and Bakshi (2005) when finding the determinant of IPM adoption. Also IPM adoption on peanuts in Georgia (McNamara, Wetzstein, and Douce, 1991), and chemical control of rice stink bug in Texas (Harper *et al*.,

1990) has age of farmer having positive effect on adoption. The adoption of IPM sweep nets in Texas was positively affected by age of farmer (Harper *et al*., 1990).

Household size has a negative and significant effect (5%) on the adoption of pesticide application relative to adopting neither practice. It is seen that a unit increase in the household size of the farmer's will decrease the relative odd ratio by 0.2596. The influence of household size on the adoption of both practices was found to be positive yet not significant but its marginal effect (0.01) was significant at 10%; showing that the relative probability of adopting both practices will increase by 1% if household size increase by one unit and this is because. This may stem from the reason that an increase in household size will mean that farmers will channel more of their income into catering for the house rather than channeling it into adopting more capital intensive technology as IPM. Also according to Ofuoku *et al* (2009), an increase in the household size will extend to the increase in the adoption of IPM among farmer in Nigeria.

Furthermore, from the result we notice that an increase in education (number of year spent on formal education) will have a positive and significant effect on the relative odd of adopting pesticide application only and adopting both practices. The relative odd ratio of adopting pesticide application relative to adopting neither of the practices will increase by 0.0699 when there is one unit increase the years spent in formal education. Also the relative odd ratio of adopting both practices relative to adopting neither of the practices will also increase by 0.1118 by a unit increase the years spent in formal education. This shows that farmers with higher number of years spent on formal education will increase the adoption of the IPM practices. For the marginal effect of number of years spent on formal education, it is seen from the table above that the relative probability of adopting pest monitoring decrease by 1%. Education is thought to reduce the amount of complexity perceived in a technology thereby increasing a technology's adoption. Studies have shown that one of the hindrances to widespread adoption of IPM as an alternative method to chemical control is that it requires greater ecological understanding of the production system. The result of this study is consistent with other studies reviewed, including Daku (2002) and Doss and Morris (2001), which revealed that education positively affected technology adoption, and the level of influence depended on the nature and type of the technology.

FBO training has a significant positive effect on the adoption of pesticide application only and the adoption of both pesticide application and pest monitoring. Form the table, a unit increase in FBO training will increase the relative odd ratio of adopting pesticide application only. The relative odd ratio of adopting both practiced will also increase. This result also shows that trained farmer in the area of IPM practices are more likely to adopt the various IPM practice bundle. In terms of marginal effect, a unit increase in number of farmer who partakes in FBO training will increase the relative probability of adopting pesticide application instead of adopting neither of the practices by 25% and decrease the relative probability of adopting pest monitoring only by 30%. Members of cooperatives get more information about improved agricultural management practices from their association than non-members of cooperatives. Moreover, it links the individual to the larger society and exposes him to a variety of ideas. Members of cooperative societies are in a privileged position with respect to other farmers, in terms of their access to information on improved agricultural technologies. The result is consistent with the finding of Singh *et al* (2008). Sharif-Zadeh *et al*., (2008) research also showed that there is a positive significant relationship between the applications of integrated pest management by farmers with membership in cooperatives

Farm size has a significant positive effect on the adoption of all the various practices bundles in the table relative to the adoption of neither of the practices. Form the table, a unit increase in the farm size will increase the relative odd ratio of adopting pesticide application only, by 0.7961. The relative odd ratio of adopting pest monitoring will also increase by 0.5973 and the relative odd ratio of adopting both practiced will also increase by 1.1305. With small farms, it has been argued that large fixed costs become a constraint to technology adoption (Abara and Singh, 1993) especially if the technology requires a substantial amount of initial set-up cost therefore making farm size of positive influence on adoption. This finding is consistent with the literature that large scale farmers are more inclined to adopt technologies than small scale farmer (Fernandez-Cornejo, 1998)

Farming on contract basis also had a positive effect on the adoption of pesticide application only, relative to the adoption of neither practices. Farming on Contract will increase the relative odds of adopting pesticide application only. Also an increase in contract farming will positively increase the adoption of pest monitoring only relative to the adoption of neither of the practices. A unit increase in contract farming will positively increase the adoption of both practices relative to the adoption of neither of the practices. It is also seen that an increase in farmers farming on contract basis will increase the relative probability of adopting both practice. The role of marketing agreements or contracts can influence pest-control decisions and outcomes thus if the marketing agreement stipulate that the grower is to produce quality produce with minimal pesticide residue, then the grower would be inclined in adopting a farming technology such as IPM that would guarantee farmer to meet the agreement and maintain his income flow (Marsh and Gallardo, 2009).

The use of hired labour is seen to have a positive effect on the relative odd ratio of the various practice bundles relative to the adoption of neither of the practices. It is seen that a unit increase in the number of farmer who employ only hire labour will increase the relative odd ratio of adopting pesticide application only, pest monitoring only and both practices (pesticide application only and pest monitoring) relative to adopting neither of the practice by 0.8124, 1.5919, and 0.8567 respectively. Also it was found that the relative probability of adopting pesticide application only instead of adopting neither of the stated practices will decrease by 15% for a unit increase in the number of farmers employing only hired labour on their farms and that of pest monitoring will increase by 23%. This result concurs' with finding of Mugisha *et al* (2004).

The availability of hired labour is seen to have a positive effect on the relative odd ratio of the various practice bundles relative to adopting of neither of the practices. It is seen that a unit increase in the availability of hire labour will increase the relative odd ratio of adopting pesticide application only, pest monitoring only and both practices (pesticide application only and pest monitoring) relative to adopting neither of the practice by 1.3622, 1.4688 and 1.0286 respectively. Since labour is of much importance in the adoption of a labour intensive practices such as IPM practices, availability of hired is of preeminent. The result shows that an increase in the availability of labour will increase the adoption of IPM. This result is in line with the work of Beckmann *et al* (2009). Also Bonabana-Wabbi *et al* (2006) found that Farm labor availability in this study positively influenced growing of improved groundnut variety Igola-1(IPM)

Distance travel by farmer to a pesticide sale point has a significant negative effect on the adoption of all the various practices bundles in the table relative to the adoption of neither of the practices. A unit increase in distance traveled will decrease the relative odd ratio of adopting pesticide application only, by 0.2453. The relative odd ratio of adopting pest monitoring will also decrease by 0.1391 and the relative odd ratio of adopting both practiced will also decrease by 0.4763. In terms of marginal effect, a unit increase in distance traveled by farmer to their farms will decrease the relative probability of adopting pesticide application only instead of adopting neither of the practices by 2% and also the relative probability of adopting of both practice relative to adopting neither practice will decrease by 2%. But it is noticed that a unit increase in the distance traveled by farmer will decrease the relative probability of adopting pest monitoring by 3%. The latter result is consistent with Erbaugh *et al* (2010) for their results shows that for each additional kilometer a farmer lives from the input source, the likelihood of adopting an additional IPM strategy increases because distance is used as a proxy for capturing the substitutability between IPM strategies and synthetic pesticides.

From the result we notice that have access to credit have a positive effect on the relative odd of adopting pesticide application only, pest monitoring but not significant. But the relative odd ratio of adopting both practices relative to adopting neither of the practices will also decrease by 0.573 by a unit increase the number of farmers who have access to credit. This shows that farmers with access to credit are less likely to adopt the both IPM practices. For the marginal effect with respect to access to credit, the relative probability of adopting pesticide application will increase by 13% for very unit increase in the number of farmers having access to credit and this result in relation with the marginal effect of adopting pesticide application only concurs' with finding of Goodwin and Schroeder (1994) and Mugisha *et al* (2004) that adoption of forward pricing increase with rise in leverage. This can be explained by the fact that access to credit enables the purchase of inputs. But relative probability of adopting both practices will decrease 13% for very unit increase in the number of farmers having access to credit.

Perception of high cost of labour has a significant positive effect on the adoption of pesticide application only and pest monitoring only relative to the adoption of neither of the practices. Form the table, a unit increase in the number of farmers with the perception that cost of labour is high will increase the relative odd ratio of adopting pesticide application only by 1.1953. The relative odd ratio of adopting pest monitoring only will also decrease by 0.8315. Also the marginal effect shows that a unit increase in the number of farmers with the perception that cost of labour is high will increase the relative probability of adopting pest monitoring only instead of adopting neither of the practices by 10%.

Extension visit has a significant positive effect on the adoption of all the various practices bundles in the table relative to the adoption of neither of the practices. Form the table, a unit increase in the number of extension visit will increase the relative odd ratio of adopting pesticide application only by 0.3450. The relative odd ratio of adopting pest monitoring will also increase by 0.3450 and the relative odd ratio of adopting both practiced will also increase by 0.4760. This shows that farmer with increased number of extension visit are more likely to adopt the IPM practices and this is because it can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies (Yaron *et al*, 1992), thus access to extensions services therefore creates the platform for acquisition of the relevant information that promotes technology adoption. This result is consistent with the work of Akudugu1 *et al* (2012).

4.3. Gross Margin Analysis of Adopters and Non-Adopters of IPM Practices

This section of the study analyses the gross margins of vegetable farmer in the Kumasi adopting and not adopting the IPM practices. The variable cost components of production and the gross returns of the sampled farmers of the selected vegetables are shown in Table 4. The table further computes the gross margins by dividing the total variable cost by the gross profit.

Table 4.8: Gross Margin Analysis for Adopters and Non-Adopters of IPM Practices

	Lettuce production		**Tomato Production**		**Spring Onion Production**	
Input	**Adopters**	**Nonadopter**	**Adopters**	**Nonadopter**	**Adopters**	**Nonadopter**

Land Preparation	300	250	300	320	310	300
seed (ha^{-1})	25	20	50	56	35	40
Herbicide (liters- ha^{-1})	30	40	40	55	25	30
Pesticide (liters- ha^{-1})	40	0	38	0	30	0
Labour	450	200	470	180	500	250
Miscellaneous	200	150	250	280	200	230
Total Variable Cost	**1045**	**760**	**1148**	**891**	**1100**	**850**
Yield (tons-ha^{-1})	10	7	8.5	5.2	10	6.4
Price (ton^{-1})	200	200	450	450	300	300
Gross Revenue	2000	1400	3825	2340	3000	1920
Gross Profit	955	640	2677	1449	1900	1070
Gross Margin	**47%**	**45%**	**69%**	**61%**	**63%**	**56%**

Source: Field survey, 2012.

Note: All costs are in GH¢ (1 USD = GH¢ 2.7, 2012)

From the table 4 below, lettuce farmers adopting the IPM retained 47% of their gross revenue as gross margin and non-adopter of the IPM practice retained 45% as their gross margin. This shows that those lettuce farmers adopting IPM attains 2% more profit than non-adopters. Cabbage farmers adopting the IPM retained 69% of their gross revenue as gross margin and nonadopter of the IPM practice retained 61% as their gross margin. This also shows that those cabbage farmers adopting IPM attains 8% more profit than non-adopters Also spring onion farmers adopting the IPM retained 63% of their gross revenue as gross margin and non-adopter of the IPM practice retained 56% as their gross margin and it shows that those spring onion farmers adopting IPM attains 7% more profit than non-adopters. The result shows that adopting of IPM is more profitable than not adopting.

Further, a sensitive analysis was carried out and this was done by finding the gross margin in two scenarios. The first scenario had an increase in the total variable cost by 10 percent and in the second scenario; the gross profit was decreased by 10%. The table below shows the result of the analysis.

From table 11 (see appendix) below, scenario 1shows there is a 4% decrease in the GM of lettuce producers who are adopting the IPM practice when TVC increase by 10% but for non-adopters there is an 5% increase in the GM. Cabbage producers in scenario 1 also have GM to decrease by 2% but non-adopters have the GM increased by 3%. Farmers adopting IPM who are into spring onion production will decrease their GM by 3% for a 10% increase in TVC and 5% for non-adopters.

Scenario 2 also shows there is a 5% decrease in the GM of lettuce producers who are adopting the IPM practice when TVC increase by 10% and for non-adopters there is a 5% decrease in the GM. Cabbage producers in scenario 2 also have GM to decrease by 2% but non-adopters have the GM decreased by 3%. Farmers adopting IPM who are into spring onion production will decrease their GM by 4% for a 10% increase in TVC and 5% for non-adopters. From the result we see that either an increase in the TVC or decrease in the gross revenue, IPM practice if adopted is more profitable than not adopting

4.4. Constraints to adoption of IPM practices by vegetable farmers

The Kendall's ranking was employ to rank the constraint to know which one is the pressing constraint. Below is a table showing the ranking of the constraint.

Table 4.9: Kendall's mean rank of Constraints to adoption of IPM practices

Constraints	Full sample	lettuce farmers	Cabbage farmers	Spring onion Farmers
	Mean rank	Mean rank	Mean rank	Mean rank
Lack of co-operation from neighboring farmer	9.01(1)	8.61(2)	9.10(1)	10.41(2)
Lack of participation in meeting and discussion	8.64(2)	8.89(1)	8.05(5)	9.23(3)
Low adoption by neighbors	8.51(3)	7.74(6)	8.86(2)	10.42(1)
Lack of timely guidance by extension functionaries	7.95(4)	8.18(3)	8.03(6)	6.38(10)
low soil fertility	7.79(5)	7.25(11)	8.48(4)	7.91(7)
Non availability of resistance varieties	7.78(6)	7.30(10)	8.72(3)	8.55(6)
Non availability of credit	7.74(7)	7.40(8)	7.67(9)	9.15(4)
High cost input	7.68(8)	7.55(7)	7.78(8)	7.71(8)
low yield	7.44(9)	6.87(12)	7.83(7)	8.64(5)
risk of revenue	7.42(10)	7.41(9)	7.62(10)	6.38(9)
Lack of education	7.31(11)	8.12(4)	6.40(13)	6.37(11)
Lack of awareness of IPM	7.08(12)	7.97(5)	6.00(14)	6.36(12)
Non availability of labour	6.48(13)	6.52(13)	6.87(11)	6.35(13)

Non availability of safe chemical		6.30(14)		33
		155	6.40(14)	6.48(12)
		6.36(13)		
N	300 122			
Kendall’s coefficient of concordance	0.21	0.31	0.19	0.25
Chi2	912.74	671.34	302.29	116.09
Df	14	14	14	14
Asymp sig.	0.00	0.00	0.00	0.00
a = Kendall’s Coefficient of Concordance				

Ranks are given in parentheses
Source: Field Survey, 2012

The Kendall’s coefficient of concordance (Wa), tests the null hypothesis that there is no agreement among the vegetable growers with respect to the constraint that prevents them from adopting IPM. The null hypothesis was rejected at a 1% significance level. The degree of agreement as measured by the W-statistics, since the score is zero for random ranking and 1 for perfectly unanimous ranking

From the table above, the most pressing constraint faced by tomato farmer in the adoption of the IPM practices is the lack of participation in meeting and discussion (mean rank = 8.89). This is followed by lack of co-operation by neighboring farmers and the third pressing constraint is the low adoption by neighbors. The least of the constraint face by tomato farmers in the adoption of the IPM practices is the non-availability of safe chemicals (mean rank = 6.30). The degree of agreement in the prioritizing the constraint of tomato farmers is 31%. Also the constraint which ranked first as most relevant to cabbage farmers was the lack of co-operation by neighboring farmers (mean rank = 9.10) followed by low adoption by neighboring farmers. The third pressing constraint to cabbage farmers is the non-availability of resistance varieties. The least relevant constraint for cabbage farmers is the lack of awareness of IPM practices. The degree of agreement in ranking the constraints of cabbage farmers is 19%. For spring onion farmers the most relevant constraint that impedes the adoption of IPM is low adoption by neighboring farmers (mean rank = 10.42). The second is the lack of co-operation from neighboring farmers followed by the lack of participation in meeting and discussion by farmers. The least relevant constraints for spring onion farmer are the non-availability of labour and non-availability of safe chemicals (mean rank = 6.30).

For all vegetable farmer in the study area lack of co-operation from neighboring farmers rank first as the most pressing constraint that impedes the adoption of IPM (mean rank = 9.01). The second ranking constraint is the lack of participation of farmers in meeting and discussion and the third is the low adoption of neighboring farmers. The least relevant constraint for the general vegetable producers in the study area is the non-availability of safe chemicals. The degree of agreement for this ranking of constraint is 21%.

CHAPTER FIVE

CONCLUSIONS

5.1. Summary of Findings

The study revealed information on the personal and household characteristic of farmers, farm characteristics, farmer awareness, adoption, perception of farmers on IPM, empirical result, constraint to adoption of IPM

It was found that farmers adopting IPM were aged (mean of 52.21) than farmers which were not adopting (non-adopter's mean age is 47.33). Males dominated in vegetable production in the study by 87% of the total sample. Majority (mean of 76.9%) the farmers attained formal education. The non-adopters of IPM had a high household size (mean of 11.9) than adopter with a mean household size of 6.30. It is also seen that adopters of IPM received high income (mean of GH₵ 1977) than non-adopters with a mean income of GH₵ 1020.2. About 76% of the farmers were members FBO.

6.3% of the farmers were not members of any FBO. Also 100% of farmers adopting the IPM practices have access to credit but none of the farmers who did not have access to credit adopted the IPM practices. About 45.3% of the farmers adopting the IPM practices were into farming and other occupation and this shows that majority of farmer adopting the IPM practices where into only farming.

The mean farm size of engaged in vegetable production in the study area is 0.54 hectares. Nonadopters of the IPM practices employed a larger farm size than that of the area of land employed by the adopters. Majority of the farmer in the study area cultivated tomato. About 13.3% of the vegetable farmers produced with a predetermined buyer. It is also noticed that majority of the farmers, both adopters and non-adopters, where not into contract farmer. About 72.3% of the farmers had visitation from extension agent. Majority (mean of 72.3%) of farmers have visits from extension agents. Adopters the IPM travel a shorter (mean of 4.8 km) than non-adopters. A high percentage of farmer (mean of 55%) employed hired labour only on their farms. Majority of farmers adopting IPM (mean of 48.6%(of farmers who have adopted the IPM practices employ hired labour only. 25% of the adopters of the IPM practices employed family labour only and 8.6% of the adopters employed both family and hired labour. 81% of the farmers are part-time farmers. 68% of farmer who are part-time farmer are adopters and 14.3% of farmers who are full-time farmer are adopters of the IPM practices.

From the studies 94% of the respondents were informed of the existence of IPM. Majority (50%) of the respondent received awareness through friends. 11% of farmer adopted the use of pest monitoring only and 56% of them adopted the use pesticide application only to control pest and 21% of the farmers adopted both pest monitoring and pesticide application.

From the health perception statement it was found that lettuce farmers agreed that IPM improves vegetable quality and reduces human health problems but disagreed to the statement that IPM reduces environmental pollution (mean perception score is 0.8, 0.9 and 0.3). Cabbage farmers agreed that IPM reduces human health problems and reduces environmental pollution but disagreed to the statement that it improves vegetable quality (mean perception score is 0.5, 0.6 and 0.4). Also it was noticed that spring onion farmers in the study area generally agrees that IPM improves vegetable quality and reduces environmental pollution but disagrees that IPM reduces human health problems (mean perception score is 0.6, 0.5 and 0.3). In terms of income perception lettuce and spring onion farmers in the study area agrees that adoption IPM increases the income and yield in vegetables production but thus not agree that adopting IPM will increase the price of vegetable. Cabbage farmers are in agreement that adopting IPM increase income but also are in disagreement with the statement that IPM increases the price of vegetable and increases yield.

From the result it is noticed that a unit increase in age, education and farm size of farmer in the study area will increase the relative odds of adopting the pesticide application only. This shows that older farmers, farmers with high educational level and farmers with large farm size are more likely to adopt pesticide application only. Also famers who are members to a FBO, farmers who produce on contract basis, farmer who employ hired labour, farmers who perceive that labour is readily available, farmers with the perception that hired labour is expensive and farmers with high number of extension visit are more likely to adopt pesticide application. Farmers with high household size and farmers who travel long distance to reach pesticide sale point are less likely to adopt pesticide application only.

Also a unit increase in age and farm size of farmer in the study area will increase the relative odds of adopting the pest monitoring. This shows that older farmers and farmers with large farm size are more likely to adopt pest monitoring only. Also farmers who produce on contract basis, farmer who employ hired labour, farmers who perceive that labour is readily available, farmers with the perception that hired labour is expensive and farmers with high number of extension visit are more likely to adopt pest monitoring only. Farmers who travel long distance to reach pesticide sale point are less likely to adopt pesticide application only.

It is noticed that a unit increase in education and farm size of farmer in the study area will increase the relative odds of adopting both IPM practices. This shows that farmers with high educational level and farmers with large farm size are more likely to adopt both pesticide application and pest monitoring. Also famers who are members to a FBO, farmers who produce on contract basis, farmers who employ hired labour, farmers who perceive that labour is readily available and farmers with high number of extension visit are more likely to adopt both practices. Farmers who travel long distance to reach pesticide sale point and farmers with access to credit are less likely to adopt both pesticide application and pest monitoring

For all vegetable farmer in the study area lack of co-operation from neighboring farmers rank first as the most pressing constraint that impedes the adoption of IPM (mean rank = 9.01). The least relevant constraint for the general vegetable producers in the study area is the nonavailability of safe chemicals. The degree of agreement for this ranking of constraint is 21%. The most pressing constraint to tomato farmer in the adoption of the IPM practices is the lack of participation in meeting and discussion (mean rank = 8.89) and the least of the constraint face by tomato farmers in the adoption of the IPM practices is the non-availability of safe chemicals (mean rank = 6.30).

The degree of agreement for tomato farmers is 31%. Also the constraint which ranked first as most relevant to cabbage farmers was the lack of co-operation by neighboring farmers (mean rank = 9.10) and the least relevant constraint for cabbage farmers is the lack of awareness of IPM practices. The degree of agreement for the cabbage farmers is 19%. For spring onion farmers the most relevant constraint that impedes the adoption of IPM is low adoption by neighboring farmers (mean rank = 10.42). The least relevant constraints for spring onion farmer are the non-availability of labour and non-availability of safe chemicals (mean rank = 6.30).

5.2. Recommendations of Study

Based on the findings of the study, the researcher makes a number of that could possibly enhance the adoption level of IPM in controlling diseases and pest among vegetable farmers in the Kumasi of Ghana.

Increase in educational level had a positive influence on the adoption of the pest control technology. Therefore it recommended that farmer will be encouraged join adult education programs in other to gain the skill of reading which will help farmer read instructions on how practice the IPM technology. The government also should establish adult educational institutes for farmer with reduced prices to make it attractive for farmers to participate. Also the government should establish more FFS for farmers who cannot go back to the classroom to join to gain the knowledge required to adopt IPM.

IPM is a cost intensive technology for controlling pest on the farm, therefore farmers will require a large capital to implement the technology. To increase adoption communities Banks and microfinance institutions should be encouraged to initiate credit programs for producers so that they can well finance to implement the technology. Government should also establish more agricultural centered financial institution like the ADB (agricultural development bank) to provide financial assistance to farmers who are willing to adopt the technology.

The study reveals that access to extension and hired labour positively influenced the adoption of IPM technology. The study also recommends that producers should endeavour to increase their contact with extension agents and use hired labour on the farms. Government and NGO extension services should be strengthened by increasing the number of extension contact with vegetable producers. Furthermore Farmer Based Organizations (FBOs) should make information IPM readily available to farmers and hence enhance their probability of adoption of IPM in controlling pest and diseases in vegetable production. It is further recommended that independent producers use hired labourers on their farms and their remuneration be catered for from sale of output from their farms. This is because family labour may not be sufficient for the labour needed for oil palm production. It is also recommended that Government and other stakeholders should provide training to vegetable producers and hired labourers on the application of agrochemicals.

5.3. Limitations and Suggestions Further Study

This study was conducted to find the factors influencing the adoption of IPM; as such there is still room for further investigation into the adoption of IPM. The following are limitation encountered during the study and suggestion made for subsequent studies.

Adoption of IPM technologies is dependent on a number of factors which are dynamic both in terms of geographic setting and in time. Thus adoption can be said to be site and time specific. The site specificity of adoption has an implication on the extensive applicability of inference made in this study in that they may have a somewhat limited bearing over a large area. Form this it is suggested that further studies should be conducted in different sites in different cities.

Because of time specificity, social, economic and other factors change and both longitudinal and cross-sectional data can be used in further studies because farmer's decision to adopted IPM is subject to change over a space of time due to changes in the factors. Over time farmers also evolve from just being aware of the technology to being experienced in the use of the technology and will choose to continue the use of the technology or not. Therefore further studies are of necessity to capture the rate of adoption of the technology.

In this study the IPM practices was limited to just two but the IPM technology has more than two practices, therefore in subsequent studies other practices can be included so as to establish the level adoption and factors affecting adoption.

The study looks at how farmer are likely to adopt the IPM technology give an increase in certain factors but in subsequent studies, a study on adaptation of farmers to IPM practices may be a necessary step. Such a study would examine how farmers adjust their economic, social and other conditions to accommodate the introduced IPM practices.

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APPENDICE

Figure 1: Trend of Agriculture Chemical Import into Ghana

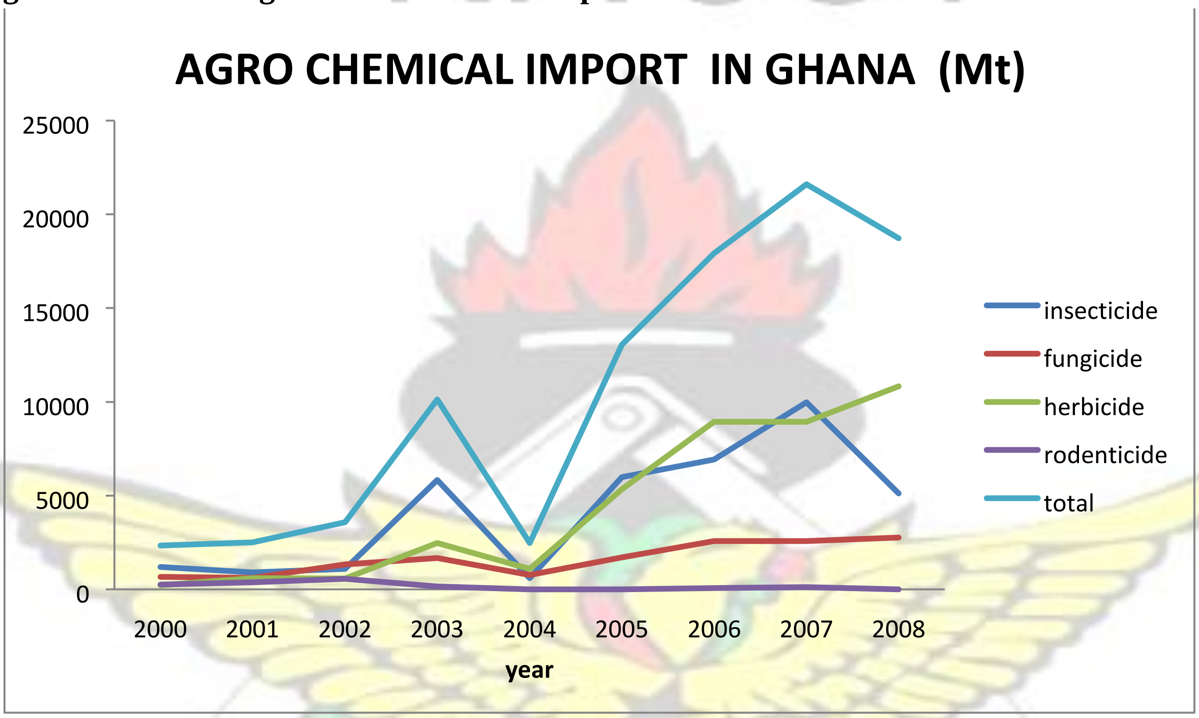

Table 11: A Sensitivity Analysis on Vegetable Production in Kumasi.

Tomatoes Production						
	Adopters			Non-adopters		
GH ¢ per ha	Reference	Scenario 1	Scenario 2	Reference	Scenario 1	Scenario 2
Total variable Cost	1045	1149.5	1045	760	836	760
Gross Revenue	2000	2000	1800	1400	1400	1260
Gross Profit	955	850.5	755	640	564	500

Gross Margin	0.47	0.43	0.42	0.45	0.40	0.40
percentage decrease		4%	5%		5%	5%

Source: Field Survey 2012

cabbage Production						
	Adopters			Non-adopters		
GH ¢ per ha	Reference	Scenario 1	Scenario 2	Reference	Scenario 1	Scenario 2
Total variable Cost	1148	1262.8	1148	891	980.1	891
Gross Revenue	3825	3825	3442.5	2340	2340	2106
Gross Profit	2677	2562.2	2294.5	1449	1359.9	1215
Gross Margin	0.69	0.67	0.67	0.61	0.58	0.58
percentage decrease		2%	2%		3%	3%

Source: Field Survey 2012

Spring onion Production						
	Adopters			Non-adopters		
GH ¢ per ha	Reference	Scenario 1	Scenario 2	Reference	Scenario 1	Scenario 2
Total variable Cost	1100	1210	1100	850	935	850
Gross Revenue	3000	3000	2700	1920	1920	1728

Gross Profit	1900	1790	1600	1070	985	878
Gross Margin	0.63	0.60	0.59	0.56	0.51	0.51
percentage		3%	4%		5%	5%
decrease						

Source: Field Survey 2012

Note: Scenario 1 indicates a 10% in the total variable cost (TVC) and scenario 2 indicates a10% decrease in the gross profit

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MPHIL AGRIC ECONOMICS

FARM HOUSEHOLD QUESTIONAIRNES

ASSESSING THE FACTORS INFLUENCING IPM IN GHANA OF VEGETABLE FARMERS IN THE KUMASI OF GHANA.

Region: …………………………………. Date of interview: ………………………..

Name of farmer: ……………………….. Metropolitan Area: …………………………….

Community: ……………………………. Telephone (mobile) number of farmer: ……….

Section A: PERSONAL AND HOUSEHOLD CHARACTERISTICS

1. Gender

   Male ☐ Female ☐

2. Age of farmer ………… Years
3. Marital status

   Married ☐ Single ☐

4. Ethnic group of farmer

   Akan ☐ Ga ☐ Ewe

   Other (specify): ……………………

5. Religion of farmer

   Christian ☐ Muslim ☐ Traditional

   Other (specify): ……………………………………..

6. What is your educational level?

   None ☐ Primary ☐ J.H.S ☐ S.H.S ☐ Polytechnic ☐ Tertiary ☐

7. What is your household size? ………………………..
8. How many people in the family are above 15 years?

   ………………………..
9. For those above 15 years, how many are income earner?

   ………………………..
10. Are you a member of any farmer-based organizations?

    Yes ☐ No ☐

    If yes, what assistance do you get from the organizations?

    ………………………………………………………………………………………………
    ………………………………………………………………………………………………
11. Does the farmer-based organization educate you on how to control pest without the application of pesticide?

    Yes ☐ No ☐
12. Have you had access to credit since you started farming?

    Yes ☐ No ☐

    If yes, what are the sources of the credit?

    Bank ☐ Family/friends ☐ Money lenders ☐ Donor organization ☐ others (specify): ……………………………………….
13. What is the amount of credit attained for farming last year?

    GH₵ …………
14. How many occupations are you involved in?

    Only farming ☐ Farming and others ☐
15. How much do you attain as income in a month (occupational income + external source if any)

    GH₵ ………….

Section B: FARM CHARACTERISTICS

16. What is your farm size?

    …………..acres

17. What is the distance your home to your farm (in miles)?

…………..miles

18. What is the type of soil on your farm

Sandy soil ☐ Clay soil ☐ Loamy soil ☐

Other (specify): ………………………..

19. What is the slope of your plot?

Gentle slope ☐ steep slope ☐ flat grounds ☐

20. What measures do you use in maintaining soil fertility?

Application of manure ☐ Application of fertilizer ☐ Growing of legume ☐

Growing of cover crops ☐ crop rotation ☐

Others (specify): ………………………

21. What type of vegetable do you grow on your plot?

Tomatoes ☐ Cabbage ☐ pepper ☐ carrot

22. How many vegetable plants do you have on an acre of your plot?

…………………………..

23. Complete the table below by filling the box without the shadings.

Crop produced	Number of bags per acre	Number of crates per acre	Kg per bag	Kg per crate	Price per bag or crate	Total area (acres) under cultivation
Tomatoes						
Onion						
Cabbage						

24. Do you cultivate vegetables on contract bases?

Yes ☐ No ☐

25. What are some of the pesticide(s) that you apply on the crops?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

26. What form of irrigation system do you practice?

Manual ☐ mechanized irrigation ☐

If you use mechanized irrigation, which system (mechanized irrigation) do you use?

Pumps ☐ canals ☐

27. What are the sources of irrigation water on your farm?

Rivers ☐ dug out wells ☐ tap water ☐

28. Do you use waste water in irrigation on vegetable farm?

Yes ☐ No ☐

If yes, give reasons why you use wastewater for irrigation?

....

....

....

29. Have you received any visit from Agricultural Extension Agent (AEA) in 2011?

Yes ☐ No ☐

If yes, how many visits? ………………………………………………

30. If yes, what assistances have you received from the Agricultural Extension Agents?

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

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

……………………………………………………………………………………………

31. How many hours do you spend working in a day?

…………hours

32. If you engage in off farm employment, how many hours of your time spent working in a day is spent on off farm activities?

…………hours

33. What type of farm labour do you employ on your farm?

Family labour only ☐ Hired labour only ☐ Both family and hired labour ☐

34. Complete the table below

Farming activities	**Family labour**	
	Male	Female

	Number employed	No of day	Number employed	Number of day
1. Clearing of land				
2. Removing of stamp				
3. Making of nursery bed				
4. Planting				
5. Weeding				
6. Watering				
7. Pesticide application				
8. Harvesting				
9. Transportation to local market				

IPM activities	**Hired labour**				
	Male		Female		Cost of labour
	Number employed	No of day/year	Number employed	Number of day/year	
1. Clearing of land					
2. Removing of stamp					
3. Making of nursery bed					
4. Planting					
5. Weeding					
6. Watering					
7. Pesticide application					
8. Harvesting					

9. Transportation to local market					

SECTION C) AWARENESS, ADOPTION AND PERCEPTIOIN OF IPM PRACTICES

35. Are you aware of any Integrated Pest Management (IPM) practice?

Yes ☐ No ☐

If yes, where did you obtain the information from?

Television ☐ News paper ☐ Farmer-based Organization ☐ MoFA ☐

Friends ☐

36. From the two choices below what IPM practices have you adopted on your farm?

IPM practices	Tick
0. Non adoption of the IPM practices	
1. Pest monitoring only	
2. Pesticide application only	
3. both pesticide application and pest monitoring	

37. Please indicate whether you agree or disagree with the following statements concerning the reduction of pesticide use when IPM is adopted(tick appropriately)

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Reduction in pesticide use will lead to an improvement in the quality of the vegetable.					
Reduction in pesticide use in farming will lead to a reduction in human health problem.					

Reduction in pesticide use will translate into increasing price of vegetable.					
Reduction in pesticide use will bring about an increase in monthly income of farmers.					
Reduction in pesticide use will bring about increase in yield.					
Reduction in pesticide use will lead to the reduction of environmental pollution.					

Section D) Constraints in IPM

38. Rate each of the constraint in order of how high the constraint reduces your rate of adoption of IPM practices.

Constraint	**Very high**	**high**	**low**	**Very low**	**none**
1. Non-availability of labour					
2. Non-availability of resistant varieties					
3. Non-availability of organic manure					
4. Non-availability of safe chemicals					
5. Non-availability of pheromone traps and lure					
6. Low soil fertility					
7. Risk of revenue					
8. loss/ low yield					
9. loss/ low yield					
10. Lack of awareness of IPM					
11. Lack of timely guidance by extension functionaries					
12. Low adoption by neighbors'					
13. Lack of co-operation from neighboring farmers					

14. Lack of participation in meetings and discussion					
15. Lack of education					
16. High cost of inputs					
17. Non-availability of cash / credit					