Pesticides Use and Safety Compliance among Rural Maize Farmers; A Case of the Sunyani West District, Ghana

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***Abstract*: - This pragmatic case study research investigates pesticides use and compliance with the recommended safety measures among less educated rural small holding maize farmers in the Sunyani West District of Ghana. Three hundred and ninety maize farmers were sampled across about three farming zones involving 15 rural communities in the study District. The types of pesticides used by maize farmers, their frequency of use and the number of pesticides used on their maize farms per the farming season as against the recommended dosage were assessed. A five-point Likert scale was used to assess farmers' awareness of the health implications of pesticides use and it was revealed that respondents were aware of the health implications of pesticides used in the study area. Also, a perception index used to assess the perception of farmers on the use of personal protective equipment (PPE) found that, farmers agree to the perception that the use of PPE is expensive and unavailable in the rural communities, financial status of rural farmers makes it difficult to purchase PPE for pesticide application and it is also important in pesticides application. However, respondents disagreed that PPEs cause discomfort to the user. A set of twelve compliance statements used to assess the extent of respondent's compliance on the recommended safety measures also found that majority of farmers were in the medium to low compliance category indicating that there was evidence of low compliance of pesticides regulations among maize farmers in the Sunyani West District. Furthermore, the estimation of the ordered logit model revealed that primary, JHS/Middle, SHS/Technical and tertiary levels of education had a significant positive correlation on pesticides use. More so, farmer's access to extension and credit facility was significant hence recorded a positive coefficient. This, therefore, implies that access to credit and access to an extension are also a significant determinant of pesticides compliance. The study therefore recommends that the government should support local industries to produce PPEs locally to make it more affordable and accessible. In addition to targeting the less educated farmers with innovative and effective flow of information dissemination and education on the proper use of pesticides.**

***Keywords:* Ghana, Rural, Maize farmers, Pesticides, Safety compliance**

I. INTRODUCTION

Ghana's economy principally depends on Agriculture and for the past few years, between 2010 and 2015 Ghana has experienced a continuous decline in GDP contribution from Agriculture from 29.8% -20.3%, hitherto, it remained a major contributor to the country's economy. This is so because most rural farm households derive their livelihood from Agriculture and it provides employment to 44.7% to the total workforce in Ghana (GSS, 2014). The total land area in Ghana is 23,852,900 hectares, out of this figure 13,620,576.9 representing approximately 57% is suitable for Agricultural use (MOFA, 2011).

With estimated tons of 1,950,000 metric tons, maize is cultivated on 1,042,000 hectares of land in Ghana. Maize in Ghana is the most widely cultivated, staple and accounts for over 50% -60% of all cereals grown in Ghana including Millet, Sorghum, Rice and second to cocoa hence significant for agricultural and food security (VOTO, 2015). Maize provides 80% of carbohydrate, 10% protein, 3.5% fibre and 2% minerals to the diets of man, animals and it is consumed by over 95% of Ghanaians in dishes such as tuo-zaafi, banku, kenkey and so on.

Its consumption was estimated at 44kg/person /year in 2005 as compared to 5.4kg/person/year increase over the 1980 level. Maize accounts for more than 45% of income from agriculture among smallholder farmers and also contributes to direct and indirect employment from, sowing, maintenance, harvesting, transporting, storage, marketing, processing, and other related activities in Ghana (MoFA, 2016).

In Ghana, 70% of maize cultivation is by small-holder farmers with an average of yield of 1.7Mt /ha as at 2013 as against the estimated yield of 6Mt/ha and growing at 1.1% annually (Darfour & Rosentrater, 2016; SRID-MoFA, 2011; IFPRI, 2014) and averagely, its importation stands at nearly 33,000MT at the cost of US8.32 Million per year between 2001 and 2010 and the majority of this importation was yellow maize, though Ghana has the capacity to be self-sufficient in maize (Afful, 2015).

The demand for food due to the increase in population is expected to double world food demand by 2050 globally. This growth has been accompanied by a demand for the quality of human life with people living longer and in better health. In Africa especially, the demand for food, will grow at an alarming rate due to increase in population as other nations, the consequences of climate change, wars, conflicts, political unrest, incidence and impact of HIV/AIDS, malaria and other diseases will cause a further decrease in human capital consequently affecting production and productivity of crops such as maize (Akoto, Andoh, Darko, Eshun, & Osei-Fosu, 2013).

The rudimentary nature of farming maize in Ghana and farmers being predominantly smallholder farmers who solely rely on rain-fed conditions for maize production and the invasion of pest further widen the gap in maize production in Ghana. These and many more reasons have made farmers resort to strategies for increasing productivity as the panacea, including the use of pesticides instead of the biological, cultural, and mechanical method of pest control, therefore, making the use of pesticides inevitable in modern agriculture (Dethier & Effenberger, 2012; Mathur, Agarwal, Johnson, & Saikia, 2005).

Pest infestation is a major constraint to maize production in the agricultural sector. It is estimated that each year pests destroy about 30-48% of the world's food including maize production. Pesticides help improve crop yield, protect crop quality and reliability as well as reducing the cost of production, increasing product quality and also ensuring high gains to farmers. Pesticide are toxic chemical substance or a mixture of substances or biological agents that are intentionally released to avert, deter, control and /or kill and destroy insect, rodents, weeds and other harmful population and include reducing pre-and post-harvest crops losses and freeing labour for other agricultural activities (Mahmood, Imadi, Shazadi, Gul, & Hakeem, 2016).

Pesticides play a critical role in food systems, but it has been established that its use could cause health implications if misused, misapplied or over-relied on. The use of pesticides lately has increased the pollution of numerous biodiversity and environmental compartments, and reports indicate that dissemination of pesticides into the environment come into contact with humans directly or indirectly through routes which include inhalation, ingestion and dermal contacts (Dey, Choudhury, & Dutta, 2013; Fianko, Donkor, Lowor, & Yeboah, 2011). Also, it has also been observed that farmers and other farm workers use chemicals pesticides and their protection is not guaranteed. These expose the applicator or farm workers to pesticides hazards through inhalation of pesticides and skin contacts (Damalas & Abdollahzadeh, 2016).

Despite the implication that pesticides pose to our health, the biodiversity, and the environment, limited information is known to the farmer who is highly at risk (Jallow, Awadh, Albaho, Devi, & Thomas, 2017). Such information is especially important in developing countries where the majority of farmers are illiterate and regulations are either underdeveloped or less enforced (Ecobichon, 2001; Eddleston *et al*., 2002). Therefore, this study sought to assess pesticides use and farmers' compliance with the recommended safety measures in the Sunyani West District.

Statement of the problem

Maize is attacked by many insect pests during all stages of growth from seedling to storage and is responsible for 15-100% and 10-60% of the pre and post-harvest losses of grains in developing countries (Mihale et al., 2009; Shiferaw, Prasanna, Hellin, & Bänziger, 2011). Pesticides use all over the world is considered as the most attractive way of controlling pests which is less labour intensive and has a higher output per a hectare of land, for the improvement of crop yield, protection of crop quality and its reliability, as well as reducing the production cost. Aside from pesticides being used in agriculture, it is also beneficial to public health in preventing vector-borne disease. Though the benefits of pesticide use are enormous, research has shown that its use is associated with some important environmental and health damages (Kumari & Reddy, 2013; Mahmood *et al.*, 2016).

The World Health Organization estimates that there are three million severe acute poisonings worldwide each year and out of this, approximately 220,000 deaths are as a result of pesticides use, of which, 1% of these deaths occur in industrialized countries and 99% happen in developing countries such as Ghana. The risks are really high on those who are exposed to the pesticides occupationally, but the demand for maize would cause the intensification of pesticide use inevitably due to the invasion of pest and demand for high-quality yields (Popp *et al*., 2013; Okoffo *et al*., 2016; Danso-Abbeam *et al.,* 2017).

In Ghana, pesticide use is characterized with non-compliance with the recommended safety measures such as abuse, misuse, and overuse of pesticides but unfortunately, there is limited information on pesticides use and what determines compliance with the recommended safety measures among maize farmers in the Sunyani West District. The study is therefore aimed at assessing the causes of misuse and abuse of pesticides among maize farmers in the Sunyani West District in the Brong Ahafo Region of Ghana. The following fundamental research questions are therefore asked:

Research Questions

1. What is the extent of pesticide use among maize farmers in the study area?
2. What is the level of awareness on the health implications of pesticides in the Sunyani West District?
3. What is the farmer's perception of the use of Personal Protective Equipment in the Sunyani West District?
4. What is the level of pesticides use compliance in the study area?
5. What are the determinants of compliance with the recommended safety measures?

Objectives

The main aim of this study was to find ways to reduce pesticides abuse, misuse, and overuse among maize farmers in the Sunyani West District. Specifically, the following objectives have been set to guide the study.

1. Assess the extent of pesticide use among maize farmers in the Sunyani West District.
2. Assess the level of awareness on the health implications of pesticides uses among maize farmers in the Sunyani west district.
3. Assess the perceptions of farmers on the use of Personal Protective Equipment.
4. Assess the extent of pesticides compliance in the Sunyani West District.
5. Assess the determinants of pesticide compliance to the recommended safety measures.

Justification of the Study

Developing countries like Ghana will continue to use pesticides in increasing quantities due to the high demand for commodities such as maize for human consumption. Invasion of pests have aggravated maize farming systems in Ghana and farmers will use more of pesticides in the production of maize than before.

It is estimated that over one-third of the world's agricultural production is lost yearly to pesticides despite the benefit it gives. Again, developing countries have been attributed to have caused more than 99% of poisoning caused by pesticides used but they only account for 20% of its users globally. This may be due to non- compliance with the recommended safety measures on pesticides use such abuse, misuse, and overuse of pesticide less protection against exposure, limited awareness on the health implications of excessive pesticides use and the low perceptions of farmers on the use of personal protective equipment among others. These factors are contributing to the deterioration of the environment, causing human ill health, negatively impacting Agricultural production and reducing the sustainability of Agriculture. The dangers of human poisoning and environmental damage could only be reduced if pesticides are applied safely and responsibly and in reference with the recommended safety measures (Boland, Koomen, de Jeude, & Oudejans, 2004), therefore the need for this study.

Scope of the Research

This study assessed the extent of pesticides used (types, frequency, and intensity) as against the recommended measures. It also assessed farmers' level of awareness on health implications of pesticide use, the perceptions of farmers on the use of Personal Protective Equipment, the extent of pesticide compliance and the determinants of compliance level among maize farmers in the study area. The study was centered in the Sunyani West District and the target respondents were maize farmers from the various Agricultural zones as grouped by the Ministry of Food and Agriculture, namely; Odomase, Chiraa, and, Nsoatre/Fiapre. The choice of the study area is due to the fact that the district is a major maize producing area, with the inhabitants being mainly farmers and are specifically into maize production.

Organization of the study

The study is organized into five sections. Section two presents, review of literature relevant to the study. The third section provides the characteristics of the study area, data collection, and details of the methodology used to achieve each specific objective. Section four presents the results and findings of the study. The study concludes on section five by offering some recommendations as the way forward.

II. LITERATURE REVIEW

This chapter presents relevant literature to the study. It begins with the definition of pesticides, the classification of pesticides, and the benefits of pesticide use among maize farmers. It also covers literature on the perception on the use of Personal Protective Equipment (PPE's), awareness on the health implications for not keeping with recommended safety measures as well as the extent of compliance and the factors determining pesticides compliance.

Pests and their control

Pests are unwanted plants or animals (which could be microbes) that are detrimental to humans or human concerns such as in agriculture or livestock production. They interfere with human activities and cause nuisance and epidemics which are associated with high mortality. They could be found in homes, industrial settings and farms. Mechanical control methods of pest control include picking of pests or their larvae by the hand, removing the part or whole plant that is affected, using traps or catching them with the help of nets. Physical control methods are by heat (high temperature kills pests), low temperature and by X-rays and Gamma rays. Cultural methods include crop rotation, deep ploughing, clean cultivation, proper use of fertilizers and water, timely or late sowing and proper harvesting. Predators such as parasites, birds, animals and micro-organisms e.g., Chelonus, Chrysopa, Trichogramma, copidosoma, *Bacillus thuringenesis* are used to control pests biologically.

Chemical methods involve the use of chemicals (pesticides) on a large scale to mitigate pests. It is effective and faster compared to other methods but is also the most hazardous to humans and the environment. Their improper use can result in resistance among various pests which could lead to extensive outbreaks resulting in the cost increase of cultivation and losses (source).

Definition of Pesticides

The term pesticide has gained much attention among international and national discussions. This could be due to the current Sustainable Development Goal 2 which aims of eradicating hunger. It could also be aligned with the current demand to provide sustainable and nutritious food production among farmers. Notwithstanding, the menace of climate change effect on food and nutrition has also caused more rural and local farmers to adopt the use of the pesticide. Food and Agriculture Organization (FAO, 1989) defined pesticide as any substance or mixture of substances that are meant to prevent, destroy or control pests during food production, processing or storage. It is also defined by World Health Organization (WHO) in collaboration with United Nations Environment Programme (UNEP) as chemicals designed to combat the attacks of various pests and vectors on agricultural crops, domestic animals, and human beings and could also be said to be anything, or substance, or virus, or bacterium, or other organisms which controls the activities of pests((WHO, 1999).

Environmental Protection Agency, a regulatory body in charge of pesticides USA, defines pesticides as a substance or mixture of substance which is used to prevent, destroy, repel, or militate against any pest. These pests include; insects, mice, or other animals, weeds, fungi, bacteria, and viruses (Jenkins and Thompson, 1999; Rewa, 2002).

Though often misunderstood to refer only to insecticides, a pesticide also applies to herbicides, fungicides, and various other substances used to control pests. In terms of what pesticide is not, fertilizers, plant and animal nutrients, food additives and animal drugs are however not classified as pesticides.

Classification of pesticides

Pests could be termed as insects, plant pathogens, weeds, birds, mammals, fishes, nematodes, and microbes that compete with humans for food, causing destruction to property, spreading of diseases and then seen as a nuisance. These have accounted for a lot of literature classifications on the pesticide. Pesticides are classified into three utmost uses. They included herbicides (44%), Fungicide (23%) and Insecticide (33%) (Ntow, Gijzen, Kelderman, & Drechsel, 2006). Synthetically, pesticides are classified based on their needs and therefore there are three most popular ways of classifying pesticides.

These are; 1. Classification based on the targeted pest species

2. Classification based on the mode of action

3. Classification based on the chemical composition of the pesticide (Drum, 1980).

Table 2.1 provides a list of some popular pesticides and the target organisms that they are meant to control.

Table 2.1: Pesticides and their targeted organism

Pesticide	Target Organism
Bactericide	Bacteria
Insecticide	Insects
Herbicide	Weeds
Fungicide	Fungi
Miticide	Mites
Rodenticide	Rodents
Algaecide	Algae
Nematicides	Nematodes
Viricide	Viruses

Source: Ray and Mondal (2017)

The World Health Organisation has presented a list of hazard categories to the identified classifications. The degree of hazard in their toxicological classes is presented in the Table 2.2

Table 2.2: Class and Definition of Pesticides

Class	Definition	Colour indication
1a	Extremely hazardous	Red
1b	Highly hazardous	Yellow
II	Moderately hazardous	Blue
III	Slightly hazardous	Green
U	Not likely hazardous	

Source: WHO, (2010)

Benefits of Pesticides

Pesticide use has become a common practice by farmers, including maize farmers due to the several claims of significance associated with its usage. According to the WHO, pesticides are used in different settings. They include but not limited to agricultural, Veterinary, Domestic, and Institutional settings but also insecticides are mostly used in developing countries and fungicides/herbicides in developed countries (IPCS, 2002; CEC, 2006; WHO, 2010). The potential benefits are particularly important in developing countries where crop losses contribute to hunger and malnutrition (Cooper and Dobson, 2007; Alewu and Nosiri, 2011; Quinn *et al*., 2011).

In Ghana's Agriculture, pesticides are traditionally used for protecting crops, for the preservation of food materials, and for the control of pests of export crops, such as Cocoa, Coffee, and Cotton (Biney, 2001; Kumari & Reddy, 2013; WHO, 1999). Lately, the use of pesticides has assumed an increasingly significant role in food crops production such as cowpea, rice, maize, and vegetables with minimal usage on cassava (NARP, 1993; Strong *et al*., 2007; Aktar*et al*., 2009). The use of pesticides also contributes to ensuring a sustainable environment. For instance, its use reduces extensive land tillage which often results in eroding arable land. Pesticides use is also an effective and faster way of cultivation as compared to other methods of pest control which requires high labour. In terms of farming on a larger scale, pesticide use saves time in treating pest and/or insecticide infestation. The need for hand weeding, using the entire family as labour has been reduced due to the use of pesticides and this generates a fourfold return on any amount spent on pesticides. The use of pesticide has also been attributed to promoting quality and increasing quantity of the commodity such as maize. There is a large range of positive outcomes from the use of different pesticides related to agricultural productivity.

Effects of pesticides use

The use of pesticide is a threat to human health, especially farmers. Their effects of long-term work-related exposure at low amounts are problematic to detect since they include transitory and non-specific health repercussions. It may also hinge on the pesticide used, means and regularity of exposure, period and application approach, not forgetting personal protective equipment use (García-García *et al*., 2016). Negative health consequences that occur due to exposure of pesticides differ according to the pesticide involved and the means of exposure, with the dermal route being the utmost, especially for sprinklers or applicators, (Atreya, 2007; MacFarlane, Carey, Keegel, El-Zaemay, & Fritschi, 2013) 2013).

Due to their wide-ranging and well-known use in agronomy and in the home setting, pesticide exposure occurs chiefly through the oral (ingestion); dermal, the eyes and nasal (inhalation); through food or from the environment (Neghab *et al.*, 2014). Contact with pesticides has also been connected with numerous health effects such as malignancies, neurodegenerative conditions, and reproductive disarrays, (Ghisari, Long, Tabbo, & Bonefeld-Jørgensen, 2015).

Symptoms of insecticides poisoning after each spraying task such as severe headache (66%), dizziness (58%), body weakness or being unusually tired (55%), nausea (53%), restlessness (37%), excessive sweating (41.3%), etc. were found in the studies (Sosan & Akingbohungbe, 2009). In another study to review the effects of Neurotoxic pesticides on hearing loss, findings indicated that exposure to Neurotoxic pesticides can induce damage to the central auditory system (Gatto, *et al*., 2014)

Chronic disease such as diabetes, Cardiovascular diseases (Hypertension), Chronic Respiratory diseases (e.g. asthma), Chronic Fatigue Syndrome, Systemic lupus erythematosus, rheumatoid arthritis, malignancies of all types, Alzheimer's, reproductive disorders, parkinsonism, nephropathy congenital anomalies etc. are key conditions affecting health of the public after exposure to pesticides, in the 21st century (Moustafalou & Abdollahi, 2013). Male reproductive activity is highly sensitive to many man-made physical and chemical agents produced by agricultural and industrial activities. There is evidence linking the reduced amount of semen to exposure to pesticides including damage to spermatogenesis (Mehrpour, Karrari, Zamani, Tsatsakis, & Abdollahi, 2014).

Globally, pesticide poisoning affects 3 million people and accounts for 20,000 unintentional deaths a year all over the world. It is also estimated that 25 million agricultural workers in the developing world suffer "an episode of pesticide poisoning each year" (Pretty, 2012; Thundiyil *et al*., 2008).

In Ghana, many farmers are unaware of the dangers of unsafe pesticide handling, misuse, and abuse which have led to a range of problems suffered by them (Ntow *et al.,* 2006; Khan *et al*., 2015). Cases of Pesticide poisoning have also been reported recently in many parts of Ghana. Example, five people passed on after consuming banku and okro soup at Akakpokope in South Tongu District of the Volta region. The Laboratory results received from Ghana Standards Authority (GSA) on the 13th of March 2018 indicated the presence of Chlorpyrifos; a very toxic substance found in commonly used pesticides which when ingested can cause death. At Abavana Down a suburb of Accra on Friday night 20th April 2018, three people were reported dead after they had inhaled a substance called organophosphate found in a product called Topstoxin, a fumigation tablet for the control of insects in stored grain and processed food and feed. In 2010, 15 deaths were reported by the Regional Health Directorate of the Upper East Region as a result of pesticide poisoning. These deaths occurred mainly due to poor storage of pesticides which seeped into food stocks. Finally, about 118 persons suffered poisoning from consuming food contaminated with pesticides (NPAS, 2012).

Pesticide Use in Ghana

As a developing and agro-based country, Ghana is experiencing economic growth and subsequently uses pesticides for national development, notwithstanding its effects on humans and the environment. Pesticide use in Ghana has increased in the number of chemicals and quantities coupled with the increase in crop yield; a response to increases in demand. Areas of application of pesticides in Ghana is concentrated in vegetable and fruits sectors, cocoa, oil palm, and the cereal sectors. Apart from physical inputs in crop production, which form less according to Ntow *et al* (2006), furthermore, 87% of farmers used one or a combination of more than one pesticide on a crop, due to their cost effectiveness. Lindane is widely used on cocoa, vegetable and maize plantations; whilst Endosulfan is mostly used on cotton, vegetables, and coffee. Ultimately Lindane and DDT use have been banned in Ghana (EPA, Ghana).

Pesticides mostly used in Ghana include chlorpyrifos, dimethoate, diazinon, cymethoate, and fenitrothion in pineapple production. Vegetables such as tomato, pepper, okra, eggplant, cabbage, and lettuce depend on pesticides such as Lambda-cyhalothrin cypermethrin, dimethoate, and Endosulfan. In Ghana, approximately 87% of farmers use chemical pesticides to control pests and diseases on crops with the majority ofusers on vegetables with a proportion 44% of herbicides, 23% fungicides and 33% of insecticides.

A study in the 10 regions of Ghana revealed that, out of the 30 organized farms selected for the study, 20 different pesticides were found to be in use with organochlorine - Lindane being the most used pesticides accounting for 35% of those applied on farms. Of the 20 pesticides found to be used, 45% were organophosphates, 30% were Pyrethroids, 15% were carbamates and 10% were organochlorines. (Ntow et al., 2006) in their findings of pesticide trade flow patterns also revealed that Ghana's Statistical Service in 1993 recorded a total of 3,854,126 tons of imported pesticides in Ghana.

An updated register of pesticides titled 'Agrochemicals and the Ghanaian Environment' from the Environmental Protection Agency in Ghana in 2008 stated that about 141 different types of pesticide products were registered in Ghana under the Part II of the Environmental Protection Agency Act, 1994 (Act 490) and these were insecticides (41.84%), herbicides (41.84%), fungicides (16.31%), and others (0.01%),(Ntow *et al.*, 2006).

The extent of Pesticide use

Ghana as a developing country has experienced high economic growth and subsequently uses pesticides to ensure feeding the populace towards achieving sustainable agriculture. The volume of pesticides used, and amount of money spent on pesticides usage illustrate that Ghana depends on them and areas with higher pesticides application are the vegetable and fruits sectors, cocoa, and the cereal sectors including maize (Lah, 2011).

Majority (86%) of farmers in the Akuapem South Municipality used different types of pesticides on their farms; the dominant active ingredients of pesticides used include deltamethrin, fenitrothion, Lindane, Endosulfan, imidacloprid and different combinations of nitrogen-phosphorus-potassium (NPK) (Omari, 2011).

The frequency of pesticide use largely depends on the type of pest to control and the crop cultivated by the farmer. In a study conducted in Nepal, more than one-third (37%) applied the pesticides more than six times while more than half (59%) and 4% of the farmers applied one to six times and no pesticide use per season respectively on their farm (Rijal *et al.*, 2018).

It was revealed in some findings that, two-thirds (67.4%) of farmers did not know the number of pesticides required for their application on the farm while 4% and 8% used more and below the recommended amount of pesticide (Omari, 2011). The pesticide intensity distribution of farmers used per hectare revealed that out of 60 pest management farmers, thirteen farmers used less than 2.5 litres, forty-five farmers used pesticides in ranges between 2.5 to 5 litres and only two farmers sprayed at 5.1 to 7.5 litres (Parveen and Nakagoshi, 2001).

Awareness of the Health implications of pesticides use

Pesticide use may influence soil and water quality and also affect the health of farmers and other pesticide users therefore extra caution of the farmer and other pesticides users is essential in pesticides application due to implications it might cause to our health (Aktar *et al.,* 2009; Banerjee *et al*., 2014; Imane *et al.,* 2016).

Pesticides again have been known to cause malfunctioning in the human immune systems. The consequence of these may cause health problems such as asthma, low sperm count and sterility in males. Also, pesticides use have been known to cause diseases such as cancer, Alzheimer's disease, type 2 diabetes, Parkinson's disease, endocrine disruption, learning, and cognitive development disorders and birth defects, prostate cancer among farmers, farm workers and people who frequently come into contact with them (Abayomi, 2018).

Children, rural residents, and those living in farms are exposed to pesticides due to the nature of their work and their locations. The implications of the pesticides on these people include in a vitro endocrine activity which is caused by the use of chemicals such as glyphosate, Chlorpyrifos, and others (Dalvie & English, 2013). Farmers' level of awareness on the implications of pesticides on human health has no influence on the farmer's way of handling and using of pesticides (Ngidlo, 2013). In a report in which respondents numbering 447 in floriculture and 481 from the general population participated, with a response rate of 98.4%, the prevalence of reported 12-month respiratory symptoms were 462 (75.5%) among flower industry workers and 232 (48.6%) among the general population. Prevalence of reported 12 months' skin symptom was 178 (37%) among flower industry workers and 68 (14.1%) among the general population (Negatu *et al.*, 2016).

This indicates a low awareness of farmers on the health implication of pesticides among floriculture association as against the general population with a less likely report of symptoms. An assessment of farmers' knowledge on pesticides in Pakistan revealed that more than half of the selected people for a study (53.8%) were aware of the implications of non-compliance of pesticides. About 39% of them believed that indiscriminate use of pesticides is detrimental to the respondents and 7.2% were of the belief that pesticides use has no health implications on its users (Aldosari, Mubushar, & Baig, 2018).

Recommendations on the need to protect their eyes, wear boots, hand gloves or to protect their nose and mouth were well understood and interpreted. This was an indication that farmers were well aware of the implications of pesticides use on health effects of human (Ajayi & Akinnifesi, 2007). As indicated in that study, the majority of farmers were not aware of the long-term implications of pesticides use. In that study again, 41.5% of farmers claimed they changed their clothing's before and after pesticides application and less than 5% washed their clothing's in water bodies close to their farms and ate without washing their hands. The effects of these behaviours include contamination as a result of dermal exposure which could lead to systemic pesticides poisoning (Fianko *et al*., 2011).

Farmers' perception on the use of personal protective Equipment

Personal Protective Equipment (PPE) is apparel and devices worn to protect the body from contact with pesticides. These include overalls, chemical-resistant suits, gloves, and footwear, and protective eyewear, respirators which are not leaking, torn, or damaged. Farmers or users of the pesticides are legally required to follow all PPE instructions on the manufacturer's label. The full compliance with chemical-resistant clothes (PPE) can reduce dermal exposure by as much as 99%. (Franke *et al.,* 2009; Yuantari *et al*., 2015)

There is an association between the perception of farmers on personal protective equipment and the use of personal protective equipment in pesticides application. A report indicates that written safety instructions of pesticides were often in English only, which could not be read and understood by farmers, who were mostly illiterate but farmers use of PPE is essential in pesticides use (Stadlinger, Mmochi, Dobo, Gyllbäck, & Kumblad, 2011). In a study carried out by (Ajayi & Akinnifesi, 2007) on farmers' understanding of pesticide safety labels and field spraying practices: a case study of cotton farmers in northern Côte d'Ivoire, revealed that farmers cited high cost of personal protective equipment, financial status of the rural farmer, the hot weather, inadequate information as the main reasons for not using personal protective equipment's in pesticides application. Also, a similar study revealed that, respondents perceived PPE are unavailable when needed (35%), its use was uncomfortable in the local hot and humid climate (90%), the price of PPE were expensive (65%), and slows you down when working (29%) as their major reasons for not using PPE in pesticides application. This indicates that farmers may not comply with the recommended safety measures on the use of PPE due to the perceptions they hold about PPE and therefore may be exposed to the hazards associated with the non-use of PPE's (Jallow *et al*., 2017).

The extent of pesticides compliance among farmers

All over the world, there is an increasing need to promote adequate protection for people involved in pesticides application to ensure their safety and decrease the damages caused due to pesticide use. Compliance with the recommended safety measures on pesticides use is therefore essential. Although the application of pesticides in developing countries is less than the developed and industrialized countries, cases of pesticide poisoning are more prevalent in developing countries. The impact is serious on farmers and farm workers. It has also been reported that there is low enforcement of the law on the use of pesticides therefore, issues of pesticides misuse and abuse is still a problem. It was reported that farmers were not adhering to the recommended safety measures on pesticides use (Mathur, *et al*., 2005).

Farmers and other users of pesticides should obtain accredited shops, read and follow the instructions given; safety equipment for the workplace should be available and strictly adhered to before applying pesticides. Also it is recommended that the farmer or the user of the pesticides should not work alone when using highly toxic pesticides and should wear the appropriate clothing that fits, and it must be clean and undamaged and therefore recommended PPE should be removed and hands thoroughly washed before eating, drinking, smoking or going to the toilet and PPE properly stored in an enclosed area (Fait *et al.,* 2001; EPA, 2017).

In a survey by (Mathur *et al*., 2005) which was conducted in Cameroon between 2001 and 2002 revealed that agrochemical accidents among farmers were attributed to low-quality spraying equipment. It was also found that 60% of environmental hazards were attributed to non-compliance with the recommended measures on pesticides disposal such as the pouring of unused pesticides into water bodies.

A survey, indicated that farmers and farm workers represented only 27% of respondents who usually read labels of pesticide; also only 16% stored their pesticides and its leftovers in a locked storage and most of the farmers and farm workers disposed their pesticides by burying (75%) throwing pesticides cans around farming fields (16%) and most of the applicators (85%) sourced their pesticides from small private shops (Negatu *et al.*, 2016). Abayomi, 2018 in a study also reported that farmers representing over, 77% did not comply with the basic recommended measures on pesticides while applying pesticides.

In Tanzania, most farmers had never seen the original packages of the pesticides, as they usually bought them already diluted or as an undiluted liquid or powder in small quantities. Most farmers have never had any form of recommendation on the use of pesticides. Instead, they were either from their colleague farmers just buying what was available in their localities. Again their mode of pesticides application was with rice husks and only a few of the respondents used a sprayer in their application and the number of pesticides applied was without the recommendation of the manufacturers (Stadlinger *et al*., 2011).

Jallow et al., 2017 have emphasized in their study that, respondents were ignorant about the proper ways of pesticides disposal, 80% of the selected farmers re-applied the leftover pesticides, and others disposed of in fields. 25% of farmers stated a recommended way of pesticides disposal by only mixing the number of pesticides needed and return leftover to hazardous waste collection sites for disposal. Unsafe practices of disposing of pesticides' containers were also noticed among the respondent farmers. They dispose off them by using a discarding the containers or burring on their farms. These poor pesticides disposal practices lead to water and soil contamination, increasing of harmful residues in harvested produce and posing health and environmental threat. Rijal et al., 2018, also indicated that despite farmers' low level of knowledge of pesticides use and the recommended safety measures, 86% of respondents used personal protective equipment in pesticides application. Also, out of the total respondents used in the study, masks, gloves, long sleeve, shoes were used by the farmers, the quality and suitability of these items of clothing were not known.

Unsafe practices are prevalent among farmers and operators in developing countries for example, in Egypt, almost all farmers stored pesticides in their bedrooms; likewise in Kenya and Palestine (Remoundou, Brennan, Hart, & Frewer, 2014). A study on the occupational insecticide exposure and perception of safety measures among cocoa farmers in South-western Nigeria showed that about 61% of the farmers stored pesticides in their homes, 31% had a separate store for pesticides, and 8% kept them on the farm. However only a few correctly disposed of empty containers (i.e. burn, destroy, bury). Almost half washed the containers and put them into various uses such as for storing palm oil and kerosene, with some throwing them away in anywhere including places to which children had access and a few resold the containers to buyers. Almost all the farmers cleaned up their spraying equipment after use. Leftover pesticides were sometimes used to spray already sprayed cacao trees or were emptied into streams or near a well at the village (Sosan & Akingbohungbe, 2009).

In order to protect the content of pesticide, containers are made of materials that have the capacity to withstand the chemical. These containers are to be stored with their original labelling including directions on application and disposal, names of the components, emergency information in case of spillage or exposure. It also includes temperatures at which the pesticides should be stored since extremes of temperatures can change the chemical structures of the product or damage the container. For safety reasons, it is best to keep the pesticide inventory to the lowest, i.e. buying only what you need per season and mixing only what you will use in a day. It is not advisable to store pesticides in food and drink containers for the safety of, especially children. If a spill is anticipated, bottled pesticides are to be stored in a larger container and tightly covered. Equipment is supposed to be stored separately away from chemicals. In the developed countries, they are stored in well lit, ventilated and fire-resistant buildings. They are to be inspected annually, must be sited away from flood-prone areas, wells, drains, ground and surface water. The building must be dry, with appropriate signs for a warning, secured under lock and key against theft and with suitable exits routes. Personal protective equipment must be kept and washed daily, separately from other clothes; work clothes must not be considered as PPE. Clean water must be available /accessible for eye flushing/irrigation in case of splashes on the face. A clean pesticide-free area for changing into and out of PPE and for storing of clean clothes and personal belongings must be available, with soap and water (US NPIC, 2015).

The Determining factors of pesticides compliance

Aldosari *et al*., 2018; Remoundou *et al*., 2014 in their Studies revealed that socio-economic factors such age, experience, sex, farm size, and others greatly influence farmers' compliance with the recommended safety measures on pesticides use. Again, Wang *et al*., 2018 reported that farmers' pesticide overuse practice is determined by socio characteristics of the farmer such as the educational background of the farmer which contribute greatly to pesticides use and adherence to safety precautions

Sex

There is a difference between the susceptibility of male and female farmers to the damages associated with pesticides use (Oesterlund *et al.*, 2014). The work of Afari-Sefa *et al*., (2015) argued that the sex of the farmer should be essential when assessing the determinants of pesticides compliance among farmers hence data of both females and males should be included in the study. Male farmers outnumber their female counterparts in farming, also males are more resourced and experience and then use pesticides with compliance with the recommended safety measures and this would, therefore, reduce the overuse in pesticides application (Wang, Chu, & Ma, 2018).

Men become more susceptible to the hazards associated with pesticides use through the mixing and application of pesticides whiles women are exposed to the residues of pesticides from the washing of clothes of their husbands which is perceived to be the role of women. In a study, two women reported that they smelt pesticides in their husband's clothes when they wash them. A cross-sectional study on pesticide use and how it affects the health of small scale farmers in Uganda also revealed that, it is important to consider the sex of a farmer since male farmers have been considered to be mostly at risk as compared to women since the heaviness of the sprayer deters women in pesticides application as compared to men who do the spraying and are therefore exposed to hazards of pesticides due to the prolong exposure (Zseleczky, Christie, & Haleegoah, 2014).

In Wang *et al*. (2018), report on measuring of rice farmer's pesticides overuse practice and the determinants revealed that male farmer's dominance in agricultural production process makes them more experienced in farming and hence they tend to apply pesticides based on their past experiences, while females tend to follow the recommended doses, therefore, causing pesticides to overuse among male farmers.

Experience

Years of farming experience have helped most farmers to learn to identify the different groups of insects in their fields. Assessment of farmers' knowledge of pesticides and training in Pakistan revealed that farmers experience in pesticides usage significantly correlates with training on pesticide usage. The farmers that possessed more experience in pesticides usage had more knowledge of alternative pest control methods and pesticide handling practices (Aldosari *et al.*, 2018; Oyekale, 2017) and experience of a farmer under normal circumstances enhances the profitability of the farmer which is very critical for poverty reduction among farmers due to their low scale of operation. In recent findings of Wang et al. (2018), they stated that experienced farmers tend to apply pesticides according to their own practices and experiences instead of following the recommended doses to avoid risks and achieve maximum profits. They again stated that farmers who have rich experience have the ability to control the amount of pesticide they use to control pests and diseases without excessively applying pesticide, and this further reduces the possibility of yield loss and income loss due to pests and diseases.

Extension services

The low number of local Agriculture extension service to farmers may be the likely reasons for the very high level of pesticide-misuse and overuse among farmers (Negatu *et al*, 2016). In spite of the implementation of national IPM Training Program in the mid-1990s, Nepal, has experienced a low adoption of IPM practices, a communication gap on information was reported between government extension workers and farmers in Rupendehi district and this resulted in almost 98% of farmers lacking the requisite training on pesticides use due to lack of extension services (Bhandari, 2014).

Age

Age of a farmer is a significant determining factor of pesticides compliance since the age of a farmer determines the level of adoption of improved technologies on pesticides use (Afari-Sefa *et al*., 2015). Age of a farmer was reported as statistically significant in the adoption of bio-pesticides. This emphasized that younger vegetable farmers have a higher or greater probability of adopting bio-pesticide in controlling pest as compared to their aged counterparts, likewise older farmers who may not want to jeopardize their investment by trying other methods (Musah, 2015). Also, Cocoa farmers' safety perception and compliance with precautions in the use of pesticides in central and western Cameroon found that, as farmers' age increases, their compliance with the recommended safety measures on pesticides use such as the wearing of protective equipment decreases. Thus, aged farmers may not be conscious of the negative health implications of coming into contact with pesticides. The implication to this may be that, as a farmer age, they acquire sufficient experience on how to handle pesticides without using protective equipment and may, therefore, be exposed greatly to the hazards associated with pesticides use (Oyekale, 2017).

Education

Many studies have revealed that education on pesticide safety prevents much of the serious exposure that causes illness or death. Through a study, it was found that educated farmers have a higher performance rate as against the non-educated farmers and also, higher adherence on pesticides use precautions is determined by education of the farmer (Bhalli et al., 2009; Adesu et al., 2018). Poor handling, frequency, and timing of pesticides reveal farmers' inadequate knowledge about pesticide use which has serious repercussions on farmers' health (Mattah, Mattah, & Futagbi, 2015).

A study on pesticides usage, perceptions, practices and health effects among farmers in North Gaza, found that there was a significant variation in the mean score of educated and non-educated respondents and that educated farmers had a higher score on healthy behaviour as compared to uneducated farmers, implying that they adhered to the recommended safety measures like reading of labels on pesticides containers, mixing pesticides using gloves, washing skin coming in contact with pesticides, washing their hands and face and also taking a bath after pesticide use. It was further found that a low level of education limits the ability of farmers to fully comprehend risks associated with the use of pesticides (Al-zain & Mosalami, 2014). In a study in Pakistan, it was reported that the likelihood of pesticide overuse reduces with higher levels of education (Rijal *et al.*, 2018).

Farm size

The farm size of a farmer has also been known to be a significant determinant of pesticides compliance. Higher acreage of a farm may be an antidote to pesticides misuse and overuse (Mattah *et al*., 2015). There is a negative relationship between the farm size of a farmer and the adoption of bio-pesticides and therefore, an increase in the farm size of farmer results in a decrease in the probability of the farmers in the adoption of bio-pesticide. On the average, each additional increase in the farm size of cabbage farmers results in 1.35 marginal decreases in the probability of adopting bio-pesticide relative to tomato and cabbage farmers; this is so because vegetable farming in the country is predominantly labour intensive (Musah, 2015).

Maize Production in Ghana

Maize (*Zea mays*) cultivation in Ghana has been known to be versatile, grown over a century of time and it is cultivated on numerous fields across the world. After its introduction in the late 16th century in Ghana, it has been known as the food crop in the country and has been cultivated in many agro-ecological zones with the majority (84%) of the production coming from the middle southern part including the Brong Ahafo, Eastern, Central, and the Ashanti and the remaining 18% been grown in the Northern regions of Ghana (Afful, 2015; Mensah, 2015; Ba, 2017).

Maize is the most cultivated in terms of area planted (about 1, 000, 000 hectares) and contributes to 50%-60% of all cereals production in Ghana. It accounts for more than 45% of agriculture income and comes second after cocoa with a higher percentage of its produce remaining in the household of producers as a primary staple food in the preparation of major dishes and a large quantity of this as a source of animal feed. 20%-25% of maize is used in industries such as breweries and provides a major source of calories and nearly replaced sorghum and millet as a traditional staple crop in northern Ghana. Its consumption is estimated at 44kg/person/year as at 2005 and it is 5.4kg/person/year increase over the 1980 level (SRID-MoFA, 2011). Maize has a greater economic value in the sense that each part of the maize plant such as the grain, leaves, stalk, tassel and the cob is used for food and non-food (Obeng-Bio, 2010; Oladejo and Adetunji, 2012; Chennakrishnan, 2012).

In Ghana, 70% of maize cultivation is by smallholder farmers with an average yield of 1.2-1.8 Mt/Ha as against the estimated yield of 6Mt/Ha as at 2013 and it is, therefore, one of the lowest globally with a growth yield of 1.1% per annum (MOFA, 2013; Ragasa, *et al*, 2013; IFPRI, 2014). Maize is grown in almost all the agro-ecological zones of Ghana except for the Sudan Savannah Zone of the Northern part and therefore has different cropping systems and technologies of maize across the agro-ecological zones of Ghana (Wood, 2013; Haruna *et al.,* 2017).

The coastal savannah zone is a narrow belt of savannah that stretches along the coast and then widens to the eastern part of Ghana. In this zone, maize and cassava are often intercropped, as their principal staples. Maize is planted at the onset of the major rains beginning in March or April, which is bimodally distributed annually. The zone is characterized by the low output of maize due to the generally light and low in fertility of the soil.

The forest zone immediately lies down the coastal savannah of Ghana. The forest of Ghana is mostly semi-deciduous, with a minimal amount of high rainforest in the South-western part of the country. Maize is intercropped with cassava, plantain, and cocoyam. Although maize is consumed in the forest zone, it is not a leading food staple and much of the crop is sold and therefore the major cash crop in the forest zone of Ghana is cocoa. Maize is planted both in the major and in the minor rainy season (March-September) (Morris, Tripp, & Dankyi, 1999).

In Ghana, the transition zone is known as the most important zone for grain production. The zone is found towards the northern part of the country with an annual rainfall which is bimodally distributed and maize planted in both the major and the minor season. Maize is cultivated as a mono-crop or intercropped with other crops.The Guinea savannah zone occupies most of the northern part of the country and is characterized by a single rainy season annually beginning in April or May. Sorghum and millet are the dominant cereals in the Guinea savannah, but maize intercropped with small grains, groundnut, and/or cowpea is also important (Morris *et al*., 1999).

III. METHODOLOGY

This section presents the theoretical and conceptual frameworks in which the study was scaffolded well as the research design, the sites, section of participants and methods of data collection and analysis.

Theoretical and Conceptual Frameworks

This study seeks to assess the extent of pesticides use and how farmers are complying with safety precautions among maize farmers. Hence, the epistemological and ontological assumptions about human nature, reality and knowledge are also oriented towards more of environmental possibilism as against determinism. Environmental determinists like Plato, Aristotle, Charles Darwin and Ellen Churchill argue that the environment, most notably, its physical factors such as landforms, soil, vegetation and climate among others, determine the patterns of human culture, capital and societal development. However, environmental possibilists advanced that, with the power of knowledge and technology, humans can alter the environment to suit their ends (Bryman, 2012). However, growing evidence have proven that the earth has a limit capacity in terms of population and waste including toxic it can carry. Hence, the need to adopt the precautionary principle or sustainable practices to protect the earth and its ecosystem to facilitate sustainable development amidst the need to increase or sustained production by curbing the increase evasion of disease vectors being fanned by global warming (Giddings, et al, 2002 Lowe, 2008; Messina, et al. 2014).

This study argues that the increasing use of pesticides by farmers is an economic and technological response by man to overcome the challenge of low crop yields due to the increasing invasion of destructive pests in Ghana. The appropriateness of the application of pesticides is to increase yield, protect the environment to ensure sustainability and to protect consumers and the farmers. The application of pesticides and adherence to safety standards will be influenced by his perceptions of its effect on his health and the health of the final consumer, the crop, his pocket and on the environment. The perceptions will be influenced by how man is applying technology to overcome the vagaries of the environment in order to maximize yield so as to meet the increasing demand for food by the ever-increasing population.

The intensification theory

This study is thus scalded by a theory dubbed agricultural intensification theory on the use of pesticides. This theory is attributed to the pioneering works of Boserup (1910-1999) and Mark Cohen (1979). The theory is consistent with the Malthus ecological theory which is also consistent with the environmental possibilism assumptions on the environment. Boserup identified two levels of intricate relationships between population growth and food supply. She argued that population growth is a function of growth in agricultural productivity and agriculture productivity which is as a result of changes in the availability of arable land; innovation also increases population growth (Atreya, 2013). Hence, the ever-increasing growth in global population has led to the recent massification of technological advancement including the use of pesticides. The increased application of pesticides has also brought about environmental and health concerns that threaten sustainability. As posited by Wilson (1998), the use of pesticides carries a significant risk of injury and illness including short-term acute illnesses such as headaches, irritation, and burns among others. It has also increased the cost of farmers about protective clothing, gloves, and face masks.

The conceptual frameworks seek to guide the researchers to select the right literature, and methods in other to properly answer the research questions to achieve the stated objectives. The conceptualization will also guide this study to explore the relationships between the adherence to pesticide-related safety standards on one hand and the farmer's level of literacy on pesticide-related safety standards. It will also help to explore the linkages between the adherence to pesticide-safety standards and farmer' level of income. It conceives that high-income farmers are more likely to buy protective accoutrement as compare to poor farmers. It also seeks to establish the relationships between pesticide-related safety standards adherence and the level of educational attainment, the level of farmer's experiences and access to extension services.

Conceptual Frameworks

The agriculture intensification theory on the application of pesticides has been summarised below. It shows the processes of agricultural intensification on the right side of the figure (Atreya, 2013). This conceptual lens also shows the relationships between the dependent variables (comprehension and correct usage of safety instructions) and independent variables (farmers' sources). Conceptualization of the intensification theory on the use of pesticides and adherence to the use of pesticides safety standards pest management information, the frequency of usage/exposures, accesses to extension service that influences farmer' inclination to adhere to safety standard associated with the use of pesticides.

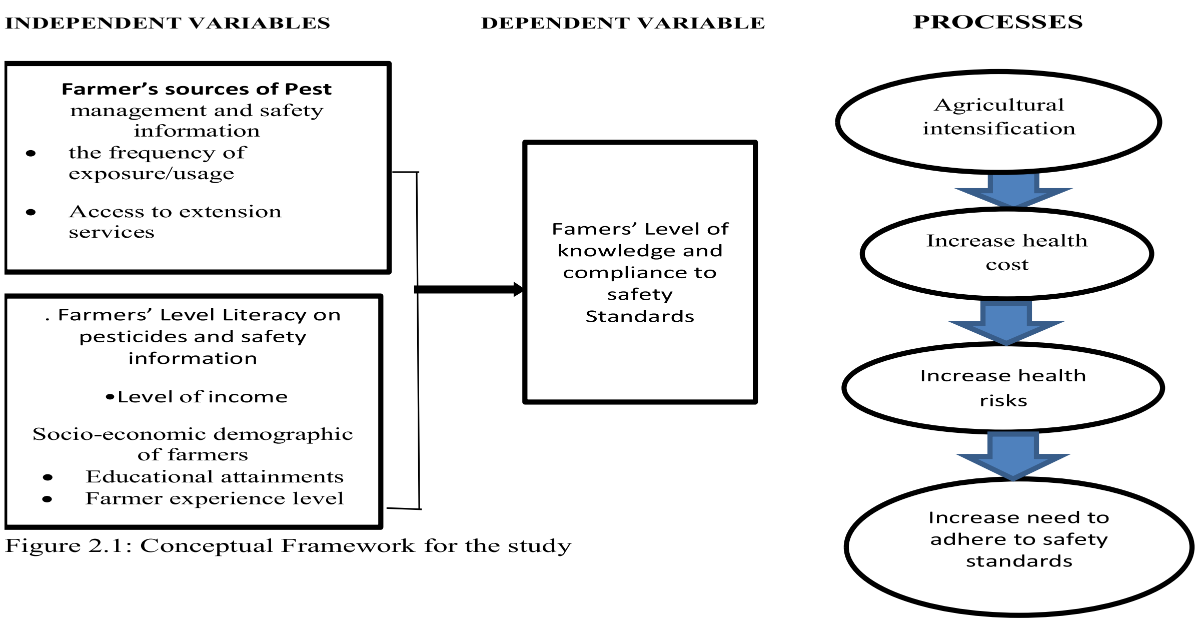

Figure 2.1: Conceptual Framework for the study

Source: Author's construction

Research Design

The study uses mix-method approach by combining both qualitative and quantitative research strands to investigate the case of pesticides use and safety compliance among illiterates rural small-scale maize farmers in the Sunyani West District.

The Study Area

The Sunyani West District Assembly (SWDA), which was carved out of Sunyani East District now Sunyani Municipal, is one of the 154 Districts in Ghana. Geographically, the District lies between latitudes 7º 19´N and 7º 35´N and longitudes 2º 08´ W and 2º 31´ W and shares boundaries with Wenchi Municipal to the North, Offinso North to the East, Sunyani Municipality to the South, Berekum Municipal to the West, Dormaa Municipal, Dormaa East to the South West and Tain District to the North West, With a total land area of 1,059.33square kilometers, the District occupies 4.2 percent of the total land area of the region. The District experiences wet semi-equatorial climatic conditions with a mean monthly temperature of about 26°C and double maxima rainfall pattern with Peak periods in June and November and an annual rainfall average of about 1700mm.The climate of the District supports moist-semi deciduous forest vegetation. The District has two main forest reserves; Tain I and II and the Yaya Forest Reserves. Some of the timber species found in the forest reserves are Odum, Mahogany, Wawa, Oframo, Teak, Kyenkyen, Sapele, and Onyina. Secondary vegetation also exists for agricultural and other land use activities**.**

Generally, the topography of the District is undulating with heights ranging between 213.36 meters along River Bisi Basin to 335.28 meters above sea level. The drainage pattern can be described as dendritic. The Tano River provides the most reliable source of water for both domestic and agricultural purposes in the lean season for communities located along with it in the District. Other rivers found in the District include River Abisu, River Sise, River Nyinahini, River Bisi, and River Bore. The soil in the district falls within the forest Ochrosols group, which makes the land fertile for the production of cash and non-crops such as maize (District analytical report). The District is predominantly a farming District with relatively high level of illiteracy, especially in the rural communities.

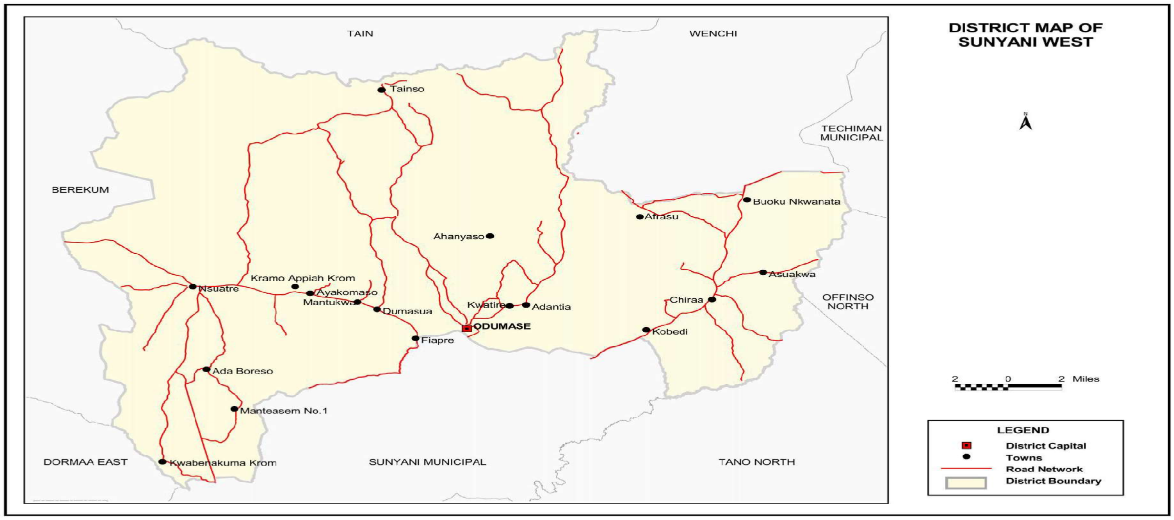

Figure 3.1: A map of Sunyani West District showing the Agricultural Zones

Sampling of Population

According to the Ministry of Food and Agriculture, Sunyani West District the population of maize farmers in the district was 22,000 maize farmers. The study employed Yamane's (1967)'s sample size determination formula in the determination of the appropriate sample size for the study. The population is 22000 maize farmers and by Yamane's formula for determining sample size.

$$n=\frac{N}{1+N(\alpha)^{2)}}$$

$$\frac{22000}{(1+22000(0.05)^{2})}$$

Where, n = the desired sample size, N = the finite size of the population (22000), α = the maximum acceptable margin of error (5%). Therefore, with a 95% statistical significance level and a known sample frame, the sample size was 390 respondents using the formula

Theparticipants were made up of maize farmers randomly selected from the three Agriculture zones with each zone containing 5 rural communities the study District. Multi-stage sampling technique was used to select maize farmers in the Sunyani West District for the study. At stage one; the study purposively selected Brong Ahafo region out of the 10 regions of Ghana. Then at stage 2, the Sunyani West District was chosen out of the 27 districts of the region. Stage 3 was the selection of maize farmers and this was done randomly. Stage 4, randomly selecting 3 communities and then systematically selecting 130 maize farmers from the three agriculture zones of MoFA making a total of 390. The communities selected are Abronye and Adoe (Odomase zone), Fiapre and Amanfoso (Nsoatre/Fiapre zone) and Kobedi and Tanom (Chiraa zone).

Table 3.1 Maize farming Communities selected from the zones for the study

Odumase	**Nsoatre/Fiapre**	**Chiraa**
Abronye	Kanturo	Kobedi
Tainso	Amanfoso	Timber Nkwanta
Boffourkrom	Kwabena Kumakrom	Tanom

Source: MOFA, Sunyani west.

Even though the proportion of maize farmers may vary for various zones, Ragasa *et al.,* (2013), in a study of the patterns of use of improved maize technologies in Ghana, randomly selected an equal number of respondents from each of 3 zones considered in the study. The selection was done randomly with no criteria attached to the selection.

The data collection was done in July-August 2018 as part of fieldwork for my Master of Philosophy thesis at the Kwame Nkrumah University of Technology, Ghana.

Instruments and Method of Data collection and Analysis

The main data collection instruments employed in the study include the use of semi-structured questionnaires and interviews. Also documentary sources of data on agriculture in the District were collated from the District and Regional offices of the Ministry of Food and Agriculture(MOFA).

The structured questionnaire consisted of both open-ended and closed-ended questions. The open-ended gave the respondents the chance to express themselves whereas the closed-ended questions, on the other hand, gave the respondents pre-coded responses in which the respondents selected the option they agree with most. The questionnaire was designed by the researcher based on literature. Data was collected by the researcher and three Agriculture extension agents from the Sunyani West District by face-to-face interviews with maize farmers in the district. Though this method of data collection is expensive, it encourages greater responsiveness. The questionnaires were designed in English and interpreted into Ashanti Twi and Bono, the local dialect in the study area.

The questionnaire was made up of six sections; Section one: demographics of the maize farmer. These include sex, zone, marital status, religion, ethnicity, and educational level of respondents. This provides types of pesticides use, respondents' farm size, Years in farming, farmer's source of pesticides, contributions of farmer Based Organizations (FBOs), Sources of Credit and access to Agriculture extension. Section Two: Assess the types, frequency, and extent of pesticides use. Section Three: This part includes behavior questions focusing on farmer's level of awareness on the health implications of pesticides use. Section four assesses the perception of maize farmers on the use of PPE's in pesticides application. Section five: assess the extent of pesticides use and the determinants of pesticides compliance among maize farmers in the Sunyani west district.

Analytical Framework

Method of Assessing the Extent of Pesticides use (Types, Frequency, and Intensity)

Objective one was analyzed using descriptive statistics, mainly frequency and percentages for the presentation of results. The type of pesticide used, the frequency of use and the intensity per hectare of maize was assessed. Cross-tabulation was used to present the findings of the type of pesticides used, the times of application and the amount used in liters per hectare of maize.

Assessing the level of awareness of the health implications of pesticide

The objective was to allow respondents to indicate their level of agreement to the awareness of the health implications of pesticides. A five-point Likert scale ranging from strongly disagree to strongly agree was used for the assessment. According to Wuensch, (2005), the Likert-type scale is a psychometric scale commonly employed in the design of questionnaires. Burns and Burns, (2008) also explained that when responding to a Likert questionnaire item, respondents specify their level of agreement or disagreement on a symmetric scale range that expresses their opinions on listed issues. The Agreement of awareness index is calculated by the addition of the product of responses for each and its respective values. The index for each statement was obtained by dividing the agreement of awareness scores by the total responses (sample size).

Perception of farmers on the use of personal protection equipment

The perception of farmers on the use of PPE was assessed using a three-point Likert scale ranging from "disagree" to "agree". The objective was to allow respondents to indicate their perception on the use of PPE. The perception index was calculated by the addition of the product of responses for each and its respective values. The index for each statement was obtained by dividing the perception scores by the total responses (sample size).

Assessing the extent of compliance with the recommended safety measures

The study adopted a descriptive approach to finding out how farmers comply with safety precautions in the study area. A yes and a no questions were posed to farmers which they responded appropriately with a tick. It was considered suitable for the objective as it involves the gathering of data from members of the population in order to determine its current status in regard to one or more variables (Mugenda & Mugenda, 1999). Moreover, descriptive studies are concerned with gathering facts rather than manipulation of variables (Bulmer, 2017). Measures of central tendencies were therefore used to analyze data collected on how farmers comply with the safety precautions on pesticides use.

Assessing the determinants of pesticides compliance

a) *Theoretical concept*

According to Lichtenberg and Zilberman (1986), the use of pesticides is considered protective inputs but not productive inputs. In general perspectives, agrochemical (pesticides and fertilizer) are used as both protective and productive inputs for maximum productivity. The safe use of recommended dosage of pesticides by a farmer is implicitly determined by the satisfaction or the utility that the farmer derives from adhering to the safety and dosage specifications. Therefore, the theoretical concept for analyzing the determinants of safe usage of pesticides is the theory of utility maximization. The utility is defined as the satisfaction that one derives from consuming a good. This definition is valid when one is looking at the theory of consumer behaviour. In this study, the utility is defined as the satisfaction (equivalently measured as the benefit) a farmer derives from adhering to safety precautions and recommended practices. The conceptual reasoning is that farmers who have a higher level of awareness about the health implications of pesticides usage are likely to adhere to the recommended safety precautions. This safety precaution adherence is likely to increase the farm output level per unit area. A maize farmer would want to be more aware of the health implications of pesticide when the utility he derives from being more compliant is greater than the utility of being less compliant. Therefore, the expected utility of a farmer who is more compliant to safety use of pesticide is higher than the expected utility of a farmer whose compliance level is low.

$$E\ (U1i) > (Ui\text{o}), (1)$$

Where $Ui1$ is the expected utility for farmers who are more aware of safety use of pesticides and $Ui0$ is the expected utility for farmers who are less aware of safety use of pesticides. The study used both descriptive and quantitative methods in analysing the sampled data. Descriptive statistics such as percentages were used while the ordered logit model was used to identify the determinants of pesticides compliance.

b) The ordered logistic model

In the literature of econometric modelling, many researchers have used binary choice models to analyze the determinants of technology adoption, perception, and awareness of certain issues. Prominent among these binary choice models are linear probability model (LPM), binary probit, and binary logit models. The probit and logit models are the improvements of the LPM but there are no significant differences between the results (Parhi, 2005). As the name suggests, the distribution of the logit model is the logistic function whereas the probit model has a normal probability distribution. In a situation where the dependent variable is polychotomous and ordered, dichotomous regression models such as LPM, binary probit or binary logit models are inappropriate. An ordered probit model or ordered logit model allows for multiple ordered values for the dependent variable (Greene, 2008). In order to use ordered logit model, the dependent variable λ was ordered. In this study, the determinants of pesticide compliance of maize farmers ordered as shown below. Theoretically, the probability of farmers in the various levels of compliance with the recommended safety measures use indicated.

λi = 1 if 0 <$\lambda * i \leq$ 1,

λi = 2 if 1 <$\lambda * i \leq$ 2,

$\lambda * i$ = 3 if 2 <$\lambda * i \leq$ 3, (3)

P (λ = 0) = ($\lambda *$ = 0) = (0 = βXi+ μi),

P ($\lambda \leq$ 1) = ($\lambda * \leq$ 1) = (1 $\leq \beta Xi$ + μi),

P ($\lambda \leq j$) = P ($\lambda * \leq j$) = (j = βXi + μi), (4)

It is important to note that the terms of the indices are 1, 2, and 3 and hence,

$u1 < u2 < u3 < u4$.

c) Empirical Ordered Logit Model.

From the theoretical ordered logit model, the empirical ordered logit model that was used to analyze the determinants of pesticides compliance

$$\text{In}\ (Pj1 - Pj) = \beta o + \beta 2\text{Sex}i + \beta 3\text{Education}i + \beta 4\text{Experience}i + + \beta 6\text{Extension}i + \beta \text{age}i + \beta 8\text{credit}i + \beta 9\text{FarmSize} + \mu i.$$

Table 3.2 also explains the description and expectations of the variables as used in the study.

The dependent variable for the study has three (3) categories of pesticides compliance. High, Medium, and Low compliance farmers. High compliance farmers are respondent who complied with all the twelve (12) compliance statements given by the researcher. Medium compliant farmers are those who complied with 8 out of the 12 compliance statements and the Low compliance category refers to farmers who complied up to 6 of the 12-compliance statements.

Table 3.2: Definitions and measurements of variables selected for the study

Variables	Description	Measurement	Expected sign
λ	compliance levels	1= Low complaints ,2= Medium compliant and 3= High compliant	
Sex	Sex	0=female,1= male	+/-
Exp	Experience	Years	+
Ext	Extension	Numbers	+
Age	Age	Years	+/-
Edu	Education	Categories	+
Acr	Access to credit	0=No, 1= Yes	+
FS	Farm size	Hectares/Acres	+

IV. RESULTS AND DISCUSSIONS

This chapter presents the results, findings, and discussions of the study. It begins with a description of the demographic variables used in the study. The data analyzed were farmers' age, Sex educational level, experience, farm size, the type of pesticides use, the frequency and intensity of use, awareness on the health implications of pesticides use, the perception of farmers on the use of PPE, the extent of pesticides compliance and the determinants of pesticides compliance among maize farmers in the Sunyani West District.

4.1 Maize Farmer Demographic Analysis

The table below shows the distribution and descriptive statistics of maize farmers in the Sunyani west district. The researcher interviewed 390 respondents who were maize farmers and have been using chemical pesticides in maize production. The sex measured as a dummy variable, marital status as a categorical variable, Religion as a categorical variable and education also measured as a categorical variable have their frequencies and percentages shown in Table4.1a.Also, other variables such as Age, Experience, and farm size which were measured as continuous variables have their means, standard errors, minimum and maximum figures displayed in table 4.1b.

Table 4.1a: Socio Demographic Characteristics of Respondents (Categorical).

Variables	Frequency	Percentage
Sex of Maize Farmers		
Males	234	60%
Females	156	40%
Marital Status		
Married	280	72%
Divorced	54	14%
Single	56	14%
Religion		
Christian	269	69%
Muslims	68	17%
Traditional	53	14%
Education		
No formal Education	143	37%
Primary	84	21%
JHS/Middle	81	21%
SHS/Tech	55	14%
Tertiary	27	7%
Access to credit		
Yes	215	55
No	175	45
Extension service		
Yes	307	79
No	83	21
Total Maize Farmers	**390**	**100%**

Source: Authors own computation, 2018

Table 4.1b: Socio-Demographic Characteristics of Respondents (Continuous)

Variables	Mean	Std. Dev.	Frequency
Age of Maize Farmers			
Male	47	11.285686	234
Female	43	8.2020091	156
Total	45	10.3531	390
Experience			
Male	15	9.850827	234
Female	9	6.5275392	156
Total	12	9.234032	390
Farm size			
Sex	6	9.67101	234
Female	11	5.7306152	156
Total			390

Source: Authors own computation, 2018

Sex

The survey revealed that out of 390 maize farmers interviewed from the Sunyani West District, 40% were females while 60% were males. This indicates an active male involvement in maize farming in the study area. Comparatively, males are more resourced and energetic therefore high participation of males in maize farming is not surprising. Though the percentage of females in maize farming in the Sunyani West District is appreciable (40%), findings from the literatureshowthat females have fewer resources and therefore less access to land for maize farming hence males would dominate in maize farming in the study area. Also, the triple roles of women namely reproduction, production and community management deny some women the time and energy to be actively involved in maize farming as compared to their male counterparts.

Marital Status and Religion

The study found that 72% of the respondents were married whiles single were 14% of the respondent's were single and 14% divorced. Christians were 69%, Muslims were 17% and Traditional believers were represented 14% out of the 390 respondents in the study area. Majority of the respondent maize farmers being Christians gives an impression that the Sunyani West District is a Christian dominated area.

Education

Table 4.2.1 shows that Maize farmers with no formal education represent 37%, primary education 21%, JHS/Middle education 21%, SHS/ Tech education14%, and Tertiary education 7%. The data gathered indicated that most of the farmers had attained levels of education that should enable them to read and write. From the literature, education is expected to positively impact pesticides compliance since educated farmers are more knowledgeable about pesticide safety, have better ability to read, understand and follow hazard warnings on labels, and conceptualize the consequences of poor pesticide usage practices. Though the majority of maize farmers in the study area were educated, their levels of education were not too appreciable with only 7% with tertiary education. This can be compared to the findings of*(Jin, Wang, He, & Gong, 2017)*.

Abdollahzadeh *et al.,*(2015) also highlighted in their study on farmers' criteria in selection Process that, farmers with higher education tendto be more aware and informed about the criteria for using pesticides more than those with less education. This might be due to the fact that educated farmers are aware of the significance of technical information concerning the pest control process and feel they further require to meet their information needs. More so, these farmers try to make better and more accurate decisions regarding the use of pesticides based on the information and awareness criteria and obtain the necessary information from various channels and resources, such as local extension agents, experts, and other farmers.

Access to credit

The study revealed that 43%of the respondents had access to loans from savings and loans groups, credit unions and rural banks. ADB Bank and GCB Bank who have been mandated to support Agriculture development in Ghana gave only 3% of the total credit received by maize farmers to support Agriculture in the Sunyani West District. The reluctance of these banks to give credit to farmers for production was due to the relatively small farm size in the Sunyani West District and their inability to meet the requirements of these banks such as education and bureaucracy in financial institutions associated with banks such as ADB and GCB BANK.

Their other sources of farm credit were from informal sources such as family, friends, and Farmer unions NGO's and others. Higher resourced farmers have a higher rate of compliance with the recommended safety measures. Farmers with access to credit are also likely to use the recommended amount of pesticides and purchase PPE for their safety.

Access to Extension

Research has shown that access to extension agents are likely to positively influence farmers on the use of the recommended safety measures on pesticides use. The numbers of visits of the agricultural extension agents were between 1, 2, 3, and more than three visits in a month with once in a month as the most practiced in the Sunyani West District. This implies that majority of the farmers had once in a month visit to their farms from the agricultural extension agents which is woefully inadequate. Farmers with more extension visitation would comply as compared to farmers with less or no access to extension agents.

Age

Mean age of the maize farmers was 45years; averagely male farmers were 45 and 43 years for females. The minimum age of 24 years and the maximum age of 76 years were recorded in the study area. This indicates that farmers are within the youthful group of the nation. Younger farmers would comply more with the recommended safety measures on pesticides use as compared to older maize farmers who could use more of pesticides to maximize gains due to ageing. This confirms Jallow et al. (2017), that, PPE, s would likely be compiled by younger farmers as compared to with older farmers.

Experience

Experience is expected to influence pesticides compliance among maize farmers in the study area. The average experience of the respondent farmers was 12 years, the mean experience for males was 15 years and that of females was 9 years in maize farming. This is similar to the report of Aldosari et al. (2018), who reported that the majority of farmers' years of experience in pesticides usage was between 11-15 years. This shows that males are more experienced in maize farming as compared to females in the Sunyani West District. This depicts the extent of pesticides exposure for farmers with low compliance with the recommended safety measures on pesticides. Therefore, implications of pesticides exposure identified to be reducing the fertility of males in men and maternal mortality in women and respiratory diseases among others are likely to occur.

Farm size

Average farm size for maize farmers in the study was 9 acres of maize in the study area, Female respondents' average farm size was 6 acres whiles the average farm size for males was 11 acres of maize in the study area. This figure shows that farmers are relatively smallholder maize farmers; therefore, they would use more pesticides to maximize profit. Also farmers with higher farms are expected to comply with the recommended safety measures because it is assumed that they are more resourced and their farms are for commercial use and would, therefore, comply not to incur losses likewise maize farmers with relatively smaller farms are subsistence farmers for household consumption and would, therefore, misapply pesticides or would not use the recommended safety measures on pesticides application on maize.

Pesticides Storage and Disposal Pattern

Table 2.4 shows how farmers pesticides are sourced, stored, disposed of, and personnel used for pesticides application. Out of the 390 respondents selected for the study, approximately 25% sourced their pesticides from Agrochemical shops, 22% had their pesticides from agriculture extension agents from their various zones and the majority representing 53% had pesticides from other sources such as family and friends. This revelation is contrary to the findings of Mattah et al. (2015) that indicated that 75% of their respondents in their study on Pesticide Application in Ghana sourced their pesticides from Agro input shops. The reason for farmers preferring to source their pesticides mainly from colleague's family and friends as compared to Agro input shops may be due to unavailability of pesticides in rural farming communities in the Sunyani west district. Respondents had various ways of storing pesticides before or after pesticides application,53% stored their pesticides in their farms, approximately 22% stored their pesticides in their bedrooms and surprisingly, it was revealed that 25%stored pesticides in their kitchens. The implications of the behaviour of farmers exhibited in this study may cause accidental poisoning and overexposure through inhalation and skin contact since they were too close to the pesticides and contact with these pesticides could be frequent; this could be detrimental to the health of farmers as well as their household detrimental to farmers. Also according to, Jallow et al. (2017), pesticides storage in homes can increase the potential for high exposure, especially when these areas are the places where farmers prepare food, eat, and sleep.

Again, the table revealed that 33% threw their personal protective equipment's away when they were worn out or damaged, 32% burnt their PPE's while 33% buried them. In a study of Damalas *et al.*, (2008), they emphasised that it is unsafe to dispose damaged PPE,s, and pesticides in fields, streams, canals but unfortunately farmers' indiscriminate way of disposing damage PPE's could end up in streams and rivers which could pollute water bodies and kill other aquatic organisms. Also burning of PPE'S such as overalls would undoubtedly release chemicals found in the pesticides into our atmosphere, subsequently causing air pollution. Farmers' way of disposing of damaged PPE is contrary to what Nesheim & Whitney, (1989) encourage the Proper way of pesticides Disposal. This risky practice exposes the lack of farmers' awareness of the health implications of pesticides exposure and the ignorance of the appropriate pesticide storage and disposal of damaged or unwanted PPE. The study further revealed that 33% of the farmers applied the pesticides by themselves, 10% of the maize farmers had their pesticides been applied by their spouses, 14% of the farmers applied their pesticides through their children, and the majority (43%) hired labour to apply pesticides on their maize farms.

Table: 4.2: Descriptive of Storage and Disposal pattern of Pesticides use

Sources of pesticide	**Frequency**	**Percent (%)**
Agro input shops	200	25%
Extension Agents	169	22%
Others (family and friends)	21	53%
Storage places of pesticides		
On the farms	209	53.59
In their bedrooms	85	21.79
In store/kitchen	96	24.62
Disposal of Damaged PPE'S		
pass on to a friend	10	2.56
Burn	124	31.79
Burry	127	32.57
Throw away	129	33.08
Applicators (personnel)		
Self	127	33
Spouse	41	10
Children	55	14
Hired labour	167	43

Source: Authors own computation, 2018

Pesticides application weather hired labour, by a spouse or self-applied should be under strict adherence with the recommended safety measures on pesticides use such as the wearing of full and recommended gear and strictly follow the recommended directions and timing in pesticides application.

Type, Frequency and Intensity of Pesticide Use

Type of Pesticides used

The type of pesticides found to be commonly used is insecticides purposively to combat the destruction caused by insect pests which have bedeviled the nation recently. From the survey, the types of insecticides found to be used by the maize farmers, their active ingredient and their hazard class as well as the distribution of frequency of pesticides used in the study areaare presented in table 4.3.

Table.4.3: Pesticides Used, Active Ingredient and their hazard class

Insecticide (Trade Name)	Active Ingredient	Hazard Class	Recommended dosage /hectare	Pre-harvest Interval
Adepa	Ethyl palmitate	U		7-14 Days
Agoo	Perisrapae Granulosis Virus +Bacillus thuringiensis	II	15-20g (powder)	20 Days
Ataka	EmamectinBenzoate (19.2g/l)	III	1litre/2 hectare	7-14 Days
Betallic super	Pirimiphos methyl(400g/l) +permethrin(75g/l)	II	1 litre/1 hectare	7-14 Days
Bypel 1	Perisrapae Granulosis Virus +Bacillus thuringiensis	II	180-270g (powder)	7-14 Days
Eradicoat	Maltodextrin (282g/l)	III	1 litre/ 2 hectare	No Interval
K-optimal EC	Acetamiprid(20g/l) +Lambda-cyhalothrin(16g/l)	II	1 litre / I hectare	14 Days
Sunpyrifos 48 EC	Chloropyrifos ethyl (480g/l)	II	1 litre/ 2 hectare	14- 21 Days
Viper 46 EC	Acetamiprid(16g/l) +Indoxacarb (30g/l)	II	1 litre / 2 hectare	14 Days

Source: Authors own computation, 2018

From table 4.3, a total of 9 insecticides were found to be commonly used in maize cultivation in the Sunyani West District. This number is in contradiction with the findings of Mattah et al. (2015) who revealed that herbicides were the most used pesticides in their study on pesticide application among farmers in Ghanaarea and were mostly in hazard category II.This is in line with the findings of Oesterlund et al. (2014). The insecticides used were mostly in WHO hazard class II, III and U. According to WHO Hazard category/class II refers to an insecticide which is moderately hazardous while III means insecticides which are slightly hazardous. Though the pesticides were in the slightly and moderately hazardous category, farmers were supposed to wear full and appropriate personal protective equipment since non-compliance with the recommended safety measures would expose users to hazards associated with it.

Table 4.4 presents the distribution of the dominant insecticide used by maize farmers. It was revealed that 10% of the respondents used Adepa. This product is a bio-rationalpesticide which is efficacious and less detrimental to humans and the environment. Due to this, the market price is a bit higher as compared to the other pesticides found to be used in the study area. Agoo was used by 5.90 % out of the 390 respondents. Agoois also a bio-pesticide and less detrimental to the environment as compared to other pesticides used in the study area. Ataka and Betallic were used by 8.72 and 6.92 respectively. Table 4.4 presents a detailed frequency of insecticides used.

Also, Bypel and Eradicoat were presented as 7.95 and 7.18% of the number of pesticides used in the area respectively. K-optimal and Viper also contributed 8.21 and 6.92% of pesticides used in the study area. Sunpyrifos representing 38.21% was the most used pesticide in the Sunyani west district for maize cultivation. The number of pesticides used is lower as compared to the report of Al-zain and Mosalami, (2014).

Table.4.4: Types and Number of persons used per pesticides

Pesticides used	Frequency	Percentage (%)
Adepa	39	10.00
Agoo	23	5.90
Ataka	34	8.72
Betallic super	27	6.92
Bypel 1	31	7.95
Eradicoat	28	7.18
K-optimal EC	32	8.21
Sunpyrifos	149	38.21
Viper	27	6.92
Total	390	100
Adepa	39	10.00

Source: Authors own computation, 2018

Frequency of pesticides use

The frequency of pesticides use was assessed by taking the number of times any of the pesticides (found in table 4.5) was applied on maize per the farming season. The type of pesticides used varied as well as the number of applications on maize per the season. Farmers' frequency range was once, twice, thrice, four, five and more times of application per the season. For the frequency of pesticides used, farmers who applied any of the nine chemicals once per the season were 24 maize farmers. One hundred and nineteen (119) maize farmers applied pesticides twice on their maize farms per season, one eighty-one (181)applied pesticides three times on maize per season, fifty-three (53) used pesticides four times per season and those who applied pesticides 5 or more times per season where thirteen (13) out of the 390 respondents.

Table 4.5: Frequencies of pesticides use per season

Pesticides	Once	Twice	Thrice Frequency	Four	Five/more	Total	
Adepa	0	4	3	0	0	7	2
Agoo	1	10	9	3	1	24	6
Ataka	3	15	14	7	2	41	11
Betallic	1	1	5	1	0	8	2
Bypel	3	10	28	9	2	52	13
Eradicoat	0	22	29	8	3	62	16
K-optimal	1	7	16	3	1	28	7
Sunpyrifos	13	44	68	20	4	149	38
Viper	2	6	9	2	0	19	5
Total	24	119	181	53	13	390	100

Source: Authors own computation, 2018

Maize farmers sampled for the study. Table 4.5 further depicts that, three times of pesticides application on maize was the practice of 181 farmers and most of the farmers. The frequency of pesticides application was not too high as compared to the findings of Jin et al. (2017), and Rijal et al., (2018) who reported an average of 10 times of application per the season and more than 6 times per the season respectively. Higher frequency of pesticides application on maize can increase the exposure of pesticides to the farmer, which may lead to health effects and possible environmental and biodiversity pollution. Farmers applying the pesticides five or more times per the season may incur a higher production cost as compared to a farmer using once or twice of pesticides per the season. This has cost and health implication resulting from the costof pesticides considering an average price of 16.00 Ghana cedis per litre of pesticides and overexposure of pesticides respectively.

The findings of this study revealed that, farmers with relatively small farm size applied more pesticides than the recommended dosage of the manufacturer and this may be due to the fact that these farmers would like to maximize their gains with their smaller farm size by applying more pesticides and the frequency of pesticides application was dependent on the surveyed maize farmers in the Sunyani west district. They also indicated that the frequency of pesticides application depended on the financial capability of farmers. This attitude of the farmers may result in the overdose and under dose of pesticides application. The implication of this is that having a bigger farm size may deter farmers from the indiscriminate use of pesticides. This supports the findings of Mattah et al. (2015)who studied pesticide application among farmers in Ghana.

Intensity of Pesticides use

The intensity of pesticide use as per this study is the number of pesticides used on maize per the farming season, measured in litres. The survey revealed that nine pesticides were found to be in use in the study area to control the invasion of pests that usually affect maize production. MOFA, Ghana has no standards on the amount and frequency of pesticides that should be applied on maize per a growing season. The manufacturer of the pesticides indicates how much of the pesticides should be used and the number of times that it should be applied on maize. Therefore, to assess the intensity of pesticides used in the study area, the nine pesticides found to be used in the study area were compared with the recommended amount of pesticides against what was used by the farmers on maize per the season. The data on farm size of maize farmers in the study area was measured in acres.

Therefore, to convert acreage to a hectare, the farm sizes of the 390 maize farmers were multiplied by 0.4 hectares.

Therefore, for 1 hectare it implies.

1/25 =0.4 Hectares thus 1 acre = 0.4 hectares.

And to calculate the amount of pesticides used per season,

= No of pesticides used (litres) / farm size (hectares)

E.g. A farmer who used 4 litres per season,

4 litres / 1.6hectares = 2.5 litres of pesticides used by the farmer per the season.

Each pesticide from the commonly used pesticide in the Sunyani west district was each compared with the amount used by the farmers as against the recommended dosage stated by the manufacturer. Based on the amount of pesticides used by the respondents, they are then categorized into low, Recommended and high intensity of pesticide use. High intensity refers to maize farmers using more than the recommended dosage of the manufacturer per a hectare of maize per season, recommended usage refers to pesticides users who used exactly the amount of pesticides on a hectare of maize per the season as recommended by the manufacturer while Low intensity refers to users who used less than the recommended amount of pesticides on a hectare of maize per the season. The full table has been presented at the appendix A of this work.

Out of the 390 respondents (table 4.6), 169 representing 43% applied pesticides higher than the manufacturer's recommendation per season, 196 of the maize farmers in the study area representing 50% used pesticides lower than the manufacturer's recommendation while 25 farmers out of the 390 maize farmers representing 7% used the manufacturer's recommendation of pesticides on their maize farms.

Table: 4.6: Intensity of Pesticides used per Hectare of maize.

Intensity	Frequency	Percentage
High Dosage	169	43%
Recommended Dosage	25	7%
Low Dosage	196	50%
Total	**390**	**100**

Source: Authors own computation, 2018

The total intensity of pesticides used was assessed by the amount of pesticides used per the season by the frequency of use. This indicates that there is evidence of overuse and underdose application of pesticides implying maize farmers' non-compliance with the recommended safety measures which could be detrimental to the health of the farmer and the environment. The higher pesticides application would result in the destruction of untargeted pest and overexposure of the dangers associated with pesticides use, likewise, underdose of pesticides application could result in resistance among various pests which could lead to extensive pest outbreaks resulting in the increase in the cost of cultivation and croplosses. This supports the findings of Parveen and Nakagoshi, (2001), where out of 60 farmers, 13 used less than the recommended dosage of 2.5 per hectare, 45 used within the recommended dosage and 2 used 5.1-7.5 litres of pesticides.

Level of Awareness on the Health Implications of Pesticides

A farmer is aware of the health implications of pesticide use is key to the appropriate handling and use of pesticides. Farmers being aware use pesticides responsibly and avert the health implications associated with pesticides use, which is known to be the cause of diseases such as the Parkinson's disease, birth defects, and cancers and so on.

To assess farmers' level of awareness on the health implications of pesticide use, the selected farmers had eight (8) questions in which they were to respond to their level of awareness on the health implications of pesticide use using a five-point Likert scale of strongly disagree (1), disagree (2), Can't tell (3), Agree (4) and strongly agree (5).The scale, the total scores, the mean for each item as well as the average awareness index has been shown in table4.7.

From table 4.7, it could be observed that the mean scores for the health implications of pesticides use ranged between 4.21 in the case of overuse causing food poisoning and 3.00 in the case of overexposure decreasing viability of sperms in males.

Table 4.7: Farmers level of Awareness on health implications of pesticides use.

Health Implications of Pesticides use	Strongly disagree 1	Disagree 2	Can't tell 3	Agree 4	Strongly Agree 5	total	mean
Over use of pesticides causes food poisoning.	9	38	15	816	765	1643	4.21
The use of pesticides contaminates aquatic bodies.	4	56	66	996	435	1557	3.99
Pesticides use causes respiratory disease to man.	8	66	72	980	400	1526	3.91
Pesticides use increase chemical residue in fruits and vegetable.	16	108	132	756	435	1447	3.71

The use of pesticides is harmful to beneficial insects.	10	192	306	508	275	1291	3.31
The overuse of pesticides decreases fertility of land.	15	278	276	356	275	1200	3.08
Over exposure of pesticides causes maternal mortality in women.	14	314	228	364	260	1180	3.03
Overexposureof pesticide decreases the viability of sperms in males.	18	322	207	352	270	1169	3.00
Average Awareness Index							3.53

1 = strongly unaware.2 = unaware; 3 = neutral; 4=aware; 5 = strongly aware

Source: Authors own computation, 2018

The total mean score of the eight (8) awareness questions on the health implications of pesticideuse was 3.53, thus indicating that, averagely, maize farmers in the Sunyani West District agreed to the awareness that, the overuse of pesticides causes food poisoning to man and animals, the use of pesticides contaminates aquatic bodies, respiratory disease can occur due to the use of pesticides, the use of pesticides increases the pesticides residues in fruits and vegetables, and the use of pesticides poses danger to beneficial insects and also decreases the fertility of land and causes maternal mortality in women and lastly decreases the viability of males sperms. This reaffirms the findings of Oyekale (2017) and Aldosari et al., (2018) who revealed a high level of awareness on issues related to the need for farmers to avoid human contacts with pesticides due to its high toxicity and 54% of farmers been aware of the health implications of pesticides use respectively.

Though the study found that farmers were aware of the health implications associated with pesticides use, surprisingly, their awareness on the implications of pesticides use did not reflect in their ways of pesticides use such as the frequency, intensity, storage and disposal of pesticides. This indicates that, even though farmers may be agreed to the awareness of the health implications of pesticides use, they may do things in their own way due to a high level of illiteracy among rural farmers. A typical example is a perception on the use of PPE.

Awareness of health implications of pesticide use by the maize farmer generally would increase the compliance level on the recommended measures on pesticides use. Also, the benefits of awareness of the health implications of pesticides would promote the maize farmer's health, increase the efficiency of pesticide use and increase the productivity of maize. This is because farmers would decrease the misuse and overuse of pesticides, there would be more time due to a decrease in the illness of the farmer thereby increasing the efficiency and productivity of the crops and farmers. Also being aware of the dangers associated with misuse and overuse of pesticides would guide the farmer to be more responsible in pesticides usage; this would further reduce the amount of money the farmer spends on excess pesticides. This money and other resources could consequently, be used in other income generating ventures.

Farmers Perception on Protective Equipment

Personal protective equipment's (PPE) are apparels and devices worn to protect the body from contacts with pesticides. In this study, PPE includes overalls or overcoats, boots, gloves, mask and, goggles. Full compliance with the recommended safety measures on pesticide use could reduce damages and disease caused by pesticide use. The study sought to assess the perception of maize farmers in the Sunyani west district on the use of personal protective equipment in pesticides application. Respondents were to answer agree, disagree and neutral to whether the prices of PPE are too expensive, or PPE are unavailable in rural farming communities, or that the financial status of the rural farmer cannot support the purchase of PPE, or whether the use of PPE causes discomfort when using, or they regard the use of PPE in pesticides application as not important at all to maize farmers in the study area.

With five perception statements, a three-point Likert scale was used to determine the average perception index of the respondent's farmers from a scale of disagree to agree (1 - 3). Table 4.8 above showed that farmers interviewed in the Sunyani West District for the study had a different perception on the use of PPE in pesticides application. With a mean of 2.9, farmers agree to the perception that PPE is unavailable in rural farming communities, they also agreed to the perception that the financial status of rural farmers makes it difficult for farmers to purchase personal protective equipment with a mean of 2.8, and with a mean of 2.6, respondents in the study area agreed to the perception that PPE is expensive. Frequencies and means for each statement and the average perception index have been provided in table 4.8.

Table 4:8: Farmer's perception on the use of PPE

Perception of farmers	Disagree (1)	Neutral (2)	Agree (3)	Total	Perception index
PPE are unavailable in farming communities.	10	1	379	390	
Scores	10	2	1137	1149	2.9
Financial status of rural farmers makes it difficult to purchase PPE.	39	5	346	390	
Scores	39	10	1038	1087	2.8
Price of PPE is too expensive.	77	1	312	390	
Scores	77	2	936	1015	2.6
The use of PPE causes Discomfort due to the hot and humid climate.	112	15	263	390	
Scores	112	30	789	931	2.4
The use of PPE is not important at all	32	4	54	390	
Scores	32	8	162	202	0.5
Average Perception Index					2.2

Scores = the frequency of response multiply by the respective value of the scale (e.g. for perception statement 1 – scores = 10*1, 1*2, 379*3).

Source: Authors own computation, 2018

However, with a mean of 2.4 and 0.5, respondent farmers disagreed to the perception that, the use of PPE causes discomfort to the user and its use are not important at all. Disagreeing to the statement that the use of PPE is not important at all indicates that selected farmers in the Sunyani West District agree that the use of PPE in pesticides application is important to the farmer. The mean perception index was 2.2.

The mean perception could not determine the exact position of the respondent maize farmers in the Sunyani west district whether they agree or disagree to the five perception statements but the majority (4 out of 5) of the perception statements agreed by the respondents. This shows that maize farmers in the Sunyani west district perceive that, the use of PPE is expensive, unavailable, the financial conditions of the rural farmer make it difficult to purchase it for their use and also its use causes discomfort. This finding is similar to that of Jallow et al. (2017) who discovered that, their respondents perceived the use of PPE as unavailable when needed, its use is uncomfortable in the local humid climate, the price of PPE is expensive and its use slows you down when working with PPE as the major reasons for not using PPE in pesticides application. Farmers with these perceptions on the use of PPE implies that they would not purchase and use these protective clothing and would, therefore, apply pesticides unprotected. This unsafe practice would, therefore, expose farmers to dangers associated with pesticides use, through routes such as the skin, nose, eyes, and diseases such as cancers, respiratory diseases, birth defects, maternal mortality, low fertility in males and Parkinson's disease and other diseases.

4.6: The Extent of Compliance with Recommend Safety Measures.

Pesticides compliance in this study refers to adhering to lay down rules and regulations on pesticides use. It also includes the manufacturer's recommendation as well as rules of other regulatory bodies such as the Ministry of Food and Agriculture, Environmental protection Authority, The Standards Authority, Food and Drugs Authority of Ghana. Also, in the study, the extent of pesticides compliance is assessed by respondents answering yes or no to twelve (12) compliance statements.

Legally and medically, farmers and other pesticides users should comply fully with the wearing of the recommended protective clothing as well as complying strictly with the manufacturer's recommendation. These include but not limited to reading of instructions on the label before applying the pesticides, proper washing of hands, wearing of overcoat/overalls, wearing of booths, wearing of gloves, goggles, mask, mixing and application of the right dosage and intensity, reuse of pesticides containers eating, smoking and tasting of pesticides, as well as the direction of pesticides application.

Table 4.9 indicates that approximately 62% of the respondents do not read the manufacturer's instructions on the pesticide's container before application of the pesticides, 54% of the respondents do not wear overcoat/overalls, 55% do not wear gloves during pesticides application, and 70% and 82% do not wear masks and goggles respectively. Appreciably, approximately 98% properly washed their hands after pesticides application and 86%wore safety booths during pesticides application. Remarkably, 97% of the respondents did not reuse their pesticides containers for any other purposes, 97% again did not smoke or eat during pesticides application and overwhelmingly, 99% did not taste their pesticides after mixing and application. Washing of hands properly after pesticides application and wearing of safety booths during pesticides application is really a good practice that may prevent contact with pesticides and the spread to our homes and consequently preventing diseases that might occur as a result of the pesticides getting contact with the pesticides. Table 4.9 present farmers' responses, their frequencies, and their corresponding percentages.

Surprisingly, the majority (more than 50%) of 390 respondents did not read the manufacturer's label wear an overall/ overcoat, wore an overcoat or an overall, wore gloves, mask, and goggles. These practices of farmers indicate that there could be an exposure of pesticides through the hands, nose and eyes and the skin which could be harmful to the health of the farmer and also exposing others such as wife and children to such dangers through the contact they may have it the pesticides through washing of the apparels and other devices and even through handshakes. It is therefore essential to comply fully with the recommended safety measures during and after pesticide application to decrease such exposures.

The findings of this study are similar to Fianko et al. (2011), who saw a similar practice and stated that the effects of their behaviours could result in contamination as a result of dermal exposure which could consequently lead to systemic poisoning. This study further reaffirms the assertion of Negatu *et al*, (2016) and Abayomi (2018), who found that the majority of the respondents could not read, wear overcoats, gloves and mask.

Table:4.9: Distribution of Compliance to Recommended Safety Measures on Pesticides use.

	NO		YES	
	Frequency	Percentage (%)	Frequency	Percentage (%)
Reading of instructions	241	61.79%	149	38.21%
Proper hands washing	9	2.31%	381	97.69%
Wearing of overcoat	212	54.36%	178	45.64%
Wearing of booths	53	13.59%	337	86.41%
Wearing of gloves	213	54.62%	177	45.38%
Wearing of masks	274	70.26%	116	29.74%
Wearing of goggles	318	81.54%	72	18.46%
Right mixing of pesticides	194	49.74%	196	50.26%
Reuse of pesticides can	378	96.92%	12	3.08%
Eat/ smoking during pesticides use	380	97.44%	10	2.56%
Tasting of pesticides	387	99.23%	3	0.77%
Direction of wind	107	27.44%	283	72.56%

Source: Authors own computation, 2018

Table 4.10 presents the extent of pesticides compliance categories of the 390 respondents used for the study. The categories were high, medium and low compliance group based on their response to the twelve statements. Out of the compliance statements, respondents that answered yes to 9-12 of the compliance statements were termed as High compliant farmers, farmers adhering to 5-8 of the twelve compliance questions were grouped under medium compliant level while respondents that answered yes to 1-4 of the compliance questions were referred to as low compliant farmers

Table: 4.10: Extent of Compliance on the Recommended Safety measures on pesticides use

Extent	Frequency	Compliance Level	Percentage
High Compliance	16	9-12 (100%)	4.10%
Medium Compliance	186	5-8 (70%)	47.69%
Low Compliance	188	1-4(50%)	48.21%
Total	390		100%

Source: Authors own computation, 2018

From the table 4.10, it is revealed that out of the 390 respondents, only 16 farmers representing 4% complied with (9-12) out the twelve compliance statements, therefore, categorizing such farmers as high compliant farmers.

Also, 186 farmers belonged to medium compliance category implying that they responded yes to 5-8 of the compliance statements and this category of farmers were approximately 48% of the 390 maize farmers in the Sunyani West District. Again, one eighty-eight (188) farmers representing 48% approximately responded yes to 1-4 of the compliance questions, therefore, these farmers were categorized as low compliant farmers. The study reveals that 96% of maize farmers representing the majority of the respondents were in the low to medium category of compliance with the recommended safety measures in pesticides application and this further explains that maize farmers in the Sunyani West District were not adhering to the use of personal protective equipment's such as booths which protects the legs of the farmer and giving stability during pesticides application, hand gloves and overall which protects the hand and body of the farmer from direct contact with pesticides and others such as goggles and nose which protects the eyes and nose of the farmer from contamination and inhalation of pesticides.

Low level of pesticides compliance found among maize farmers in the Sunyani West District further exposes farmers to the risk, dangers, and death associated with the use of pesticides. This is in line with the findings of (Stadlinger et al. (2011)who also saw low pesticide compliance with basic recommended measures among farmers.

Assessing the Determinants of Pesticides Compliance

The study also sought to assess the factors determining pesticides compliance among maize farmers in the Sunyani west district. The researcher used the ordered logistic regression model to determine the factors responsible for pesticides compliance. The choice of the model was because; it works perfectly due to the ordered meaningful categorical nature of the dependent variables (high, medium and low compliance).The multinomial logistic regression mode though similar to the ordered logistic regression could not be used because it has to be assumed that there is no order to the categories of the outcome variables. The downside to this approach is that the information contained in the ordering would be lost. The independent variables used for the regression are sex, experience, extension, age, access to formal education, access to credit and farm size. Table 4.11 shows the descriptive statistics (observations number, mean, standard deviation, minimum and maximum limit) of the variables used in the ordered regression.

Table 4.11: Descriptive Statistic for Variables used in Ordered Logit Regression

Dependent Variable	Obs	Mean	Std Dev	Min	Max
Compliance Level	390	1.559	.5739494	1	3
Independent Variables					
Sex	390	0.60	.4905272	0	1
Age	390	45.12821	10.3531	24	76
Formal Education	390	.6333333	.4825134	0	1
Access to Credit	390	.5512821	.4980021	0	1
Farming Experience	390	12.4641	9.234032	2	40
Farm Size	390	8.842308	8.693518	1	50
Access to Extension	390	.7871795	.4098275	0	1

Source: Authors own computation, 2018

Table 4.12. below displayed the estimate of the ordered logistic regression model. The final log likelihood (-299.35894) is displayed. All the 390 observations in our data set were used for the analysis. The likelihood ratio chi-square of (53.27) with a p-value of 0.0000 tells us that our model as a whole is statistically significant and the pseudo-R-squared of 0.0817 is also given. In the table, we see the independent variables, their respective coefficients, their standard errors, their associated p-values, and their odds ratio. The cut points 1 and 2 shown at the bottom of the output indicate the other two levels where the latent variable is cut to make the three groups that we observe in our data.

From table 4.11 above, out of the seven (7) variables selected by the researcher, sex, experience, access to credit and farm size of the maize farmers in the study area were found to be statistically insignificant and therefore considered not to be determining factors of pesticide compliance among maize farmers in the Sunyani West District. This, therefore, indicates that a change or an increase in the variables would not affect farmers compliance with the recommended safety measures in pesticide use

Table 4.12: Estimation of Determinants of Pesticides compliance

Variables	**Coeffient**	**Std Error**	**P> values**	**Odds Ratio**	**Std Error**
Sex	.142632	2394132	0.551	1.153305	.2761165
Experience	-.0134933	.0165088	0.414	.9865973	.0162875
Extension	.5282161*	.2978781	0.076	1.695904	.5051728
Age	.0292665**	.0140464	0.037	1.029699	.0144636
Formal education	1.294771***	.2321315	0.000	3.650159	.8473169
Access to credit	.3622547	.2456928	0.140	1.436565	.3529536
Farm size	-.0015039	.0133402	0.910	.9984973	.0133201
Cut 1	2.585163	.5945594		2.585163	.5945594
Cut 2	6.066727	.6790579		6.066727	.6790579

Ordered Logistic Regression — Number of observations = 390
LR chi2 (7) = 53.27
Log likelihood = -299.35894 — Prob > chi2 = 0.0000
Pseudo R2 = 0.0817

Source: Authors own computation, 2018

However, access to extension, age and formal education of the maize farmer were found to be statistically significant. Access to an agricultural extension was significant with a P value of 0.076 and a positive coefficient of. .5282161 and odds ratio of 1.695904. This implies that it is a significant determinant of pesticides compliance among maize farmers in the Sunyani West District and the positive correlation denotes that an increase of extension visits by 1.7 times would cause the farmer to be in the higher compliance category. In a recent study of (Negatu et al, 2016), a low number of agricultural extension visitations to farmers may be the likely reasons for very high pesticides misuse and overuse among farmers. Likewise, an increase in the extension visitations to the farmer would cause farmers to be abreast with safety and compliance issues and more equipped with new and sustainable ways of pesticides application. This, in turn, will decrease health and environmental damages associated with pesticides use. Also, farmers with an increase in the visitation of the agriculture extension agents may have greater access to information on the safe use of pesticides and may also be informed on the health implications associated with the use of pesticides without protective accoutrements.

Age according to literature could have a positive or negative influence on pesticides compliance. This study found that the age of the maize farmer in the Sunyani West District had a positive correlation with pesticides compliance. With a positive coefficient of .0292665 at5%, a P value of 0.035 and odds ratio of 1.029699. This indicates that an increase in an age of a maize farmer in the study area by a year would cause the farmer to be in the higher level of pesticides compliances, therefore, the higher the age, the higher the compliance level in pesticides usage among maize farmers in the study area. This revelation supports the finding of Aldosari et al. (2018),on Assessment of farmer's knowledge on pesticides and training in Pakistan who revealed that age of a farmer significantly correlates with pesticides usage.

Formal education of maize farmer in the Sunyani West District was found to be a significant determinant of pesticides compliance. In line with literature expected relation, formal education had a positive relationship with the compliance of the maize farmers in the Sunyani West District, positive coefficient of 1.294771at 1%, and a P value of 0.000.The implication to this is that an increase of 3.650 years of formal years of education would cause a farmer to be in the higher pesticide compliance category as compared to farmers with no formal education among maize farmers in the Sunyani West District. This revelation is in line with the findings of (Bhalli et al., 2009; Adesu et al., 2018). Higher pesticide compliances among farmers have been attributed to a higher level of education which might avoid intoxication risks; this is so because educated farmers can read and understand labels on pesticides containers and comply with the precautions of the manufacturer. Higher Educational attainment decreases the probability of a farmer being in the low level of pesticides compliance and this would avert health and environmental damages associated with pesticides use. Also,

V. SUMMARY, CONCLUSION, AND RECOMMENDATION

This final section presents the summary of the background information, statement of the problem, the objectives and the main findings of the study. Also, it presents conclusions and recommendations for policymakers and for further research.

Summary

For over nine hundred (900) million poor people and over one-third of all malnourished children, maize is the number one food source. In Ghana, maize is the highest and the most cultivated crop cultivating 992,000 hectares of the total land area of Ghana Foods from maize sources are consumed by approximately 95% of Ghanaians(Akoto et al.,2013; Akoto et al,2013 and MoFA, 2016). Due to the invasion of pest and the demand for quality yield and the increasing demand for maize, pesticides use is inevitable in maize production. The destruction caused by the pest is estimated to be 30-48% of the food produced globally each year Mahmood, et al., (2016).

In spite of the damage caused by pest in maize production, the use of pesticides in Ghana is characterized by non-compliance on the recommended safety measures on pesticides use resulting from the types and the extent of use, farmers low awareness on the health implications of pesticides, the perception of farmers on the use of PPE in pesticides applications and many other factors.

The study sought to assess the extent of pesticides use and how farmers were complying with recommended safety measures on pesticide use. The primary data used for the research was obtained from a cross section of 390 maize farmers in nine communities in the three (3) Agricultural zones in the Sunyani west district using a structured questionnaire. Descriptive statistics such as percentages, frequency tables, means, and percentages were employed in the qualitative analyses while quantitatively the ordered logit model was used to assess the determinants of pesticides compliance.

It was concluded that the majority of maize farmers in the Sunyani west district were males, an indication of active males' involvement in maize farming in the study area. A higher proportion of the respondents had some level of formal education, with onlya less than10% having tertiary education. Though they had formal education, and their levels of education were too low since only 6.92% had tertiary education. Again, it was concluded that farmers in the Sunyani west district were predominantly small-scale farmers with an average farm size of 9 acres and a minimum and maximum of 1 and 50acres respectively. The most experienced farmer had 40 years in maize farming, therefore, the implication was that farmers with long years in maize farming might have had an experience in maize farming and again might have been using pesticides for some number of years and consequently been exposed to the hazards associated with the use of pesticides if not fully protected.

Again, it has been concluded (Akoto et al., 2013) the types of pesticides been used in the Sunyani west district were mainly insecticides and the commonly used insecticides was Sunpyrifos. The frequency of use was mainly thrice by per the farming season. The study of awareness on the health implications of pesticides use revealed that selected maize farmers in the Sunyani West District averagely agreed that they were aware that food poisoning, contamination of aquatic bodies, respiratory disease and increase in chemical residue in fruits and vegetables, pesticides use causing harm to beneficial insects, causing maternal mortality in women, and low viability of sperms in males were also health implications of pesticides use

Perception studies concluded that farmers agreed that the price of PPE is too expensive, PPE is unavailable in their rural farming communities, the poor financial status of the farmer and high level of illiteracy among rural farmers are what they perceive to be the reasons for non-use of PPE in pesticides application. However, respondents disagree that the use of PPE is not important at all in pesticides application implying that, the use of PPE in pesticides application is important.

The ordered logit model made a revelation that determinants of pesticides compliance such as sex, educational level of the maize farmer, access to credit and maize farm size of the respondent were statistically significant implying that, they have a significant effect on a farmer's compliance with pesticide regulations.

The level of pesticide compliance among maize farmers in the Sunyani West District had been concluded that the majority of them were found to be in the low to the medium category of pesticide compliance. Again, it was found that the least complied personal protective equipment was the use of goggles in protecting the eye during pesticides application. Half of the 390 maize farmers selected for the study mixed their pesticides with others, a common practice which causes pests to develop resistance to other chemical pesticides.

Recommendations

1. Access to credit

Commercial Banks mandated to promote agriculture development in Ghana through financing such as the ADB Bank should be well resourced to support and encourage farmers to take loans to support their farming and to purchase pesticides protective equipment to reduce hazards associated with pesticide use.

2. Promoting Education among rural farmers

Education has been known to have a significant effect on pesticide compliance. Educated farmers are likely to comply with the recommended safety measures on pesticides use. Education, training, and dissemination of information should therefore highly target illiterate farmers. Stakeholders, such as the Ministry of Food and Agriculture (MOFA) and Non-Formal Education Division of the Ministry of Education should provide maize farmers with special training in reading, writing, and numeracy to enhance their knowledge on the safe use of pesticides.

3. Creating Awareness on the accessibility of bio-rational pesticides

The farmer should be made aware of the existence of bio-rational pesticides in our markets lately and take advantage of them. These chemicals though relatively expensive as compared to the other pesticides, they are more efficacious and less detrimental to the environment and biodiversity.

4. Awareness on the health implications of pesticide use

Awareness of the health implications of pesticide use should be incorporated into farmers training and education to reduce the overuse of pesticide and its associated hazards. The government, MOFA, EPA, and other stakeholders should intensify the monitoring of farmers with regards to pesticide application and the use of personal protective equipment in rural farming *communities*.

5. Accessibility and affordability of PPE

The government should support local industries to produce PPE locally. This would make PPE affordable and highly accessible even in rural farming communities and overall coats should be made disposal to avoid contamination due to storage or wash. Farmers should use selective rather than broad-spectrum pesticides to avoid killing untargeted pest and ensuring the sustainability of beneficial insects and natural enemies such as spider, beetle, and ants.

6. Enforcement of rules and regulations on non-compliance of Pesticide measures

High compliance with the recommended safety measures on pesticide use decreases the probability of poisoning related to pesticides use whereas lack of PPE use increases the cause of dermal and respiratory disease due to pesticides use. According to the study, most farmers were categorized under low to medium compliance, therefore the government should ensure strict compliance with the recommended safety measures.

Contribution to the body of literature

Previous studies on pesticides usage focused on perceptions on the use of PPE awareness on the health effects on pesticide, knowledge, and practices in pesticides use. Such works include Ntow et al. (2006) and Oyekale (2017). This work as compared to other works is unique in the sense that it assesses the determinants of compliance using the ordered logistic regression model and the factors contributing. Again, there is no evidence of such work carried in the Sunyani West District; the study area.

Policy Implication

The findings of this work stressed on the need for policy makers to strengthen the education on the right amount of pesticide usage and the strict compliance of PPE to avoid the misuse and abuse of pesticides and the possible hazards associated with it and also factors that determine compliance among farmers especially maize farmers in the Sunyani West District would guide policymakers in decisions and programmes.

Areas of Further research

The researcher suggests that, for further research purposes on pesticides use and safety compliance among farmers, the six ecological zones of Ghana should be the study area so that the results and findings obtained could be used to generalize the pesticides use and safety compliance in Ghana. Moving on in research, this study was specifically on maize, other researchers should consider having other works on different crops such as vegetables which highly depends on pesticide use to assess the extent of pesticide compliance among its farmers.

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