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Effectiveness of Pesticide Safety Training on Farmers' Knowledge and Practices in Vegetable Production: Evidence from Small-Scale Farmers in Kasena Nankana Municipality, Upper East Region of Ghana

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Abstract

The current study examined the use of pesticides and their safety practices among smallholder vegetable farmers in the Kassena-Nankana Municipality of the Upper East Region, Ghana. A sample size of 95 vegetable farmers who engaged in dry season vegetable farming was considered. Data collection was done using interview guide and structured questionnaire, and data analysis was done using descriptive statistics including frequencies, mean, and standard deviations. The most (49%) cultivated vegetable was pepper, followed by garden eggs (26%) and tomatoes (25%). Generally, 64.2% of farmers claimed that they had taken pesticides safety training in the last two years, whereas 35.8% did not take any pesticides safety training. Of the total farmers who took the training, the majority (83.6%) found the training useful, while 16.4% felt otherwise. Mostly, 54.1% of training was conducted in farmers' farm field, and hence the importance of practical approach cannot be underestimated. Insecticides were the mostly (74.7%) used pesticides, followed by fungicides (15.8%) and herbicides/rodenticides (9.5%). Despite the fact that 58.9% of farmers knew about the health effects of pesticides, 41.1% were ignorant of it. Similarly, (65.3%) were unaware of government-banned pesticides, raising concerns about the potential use of prohibited products. Economic considerations strongly influenced pesticide selection, with (47.4%) citing price and (31.6%) citing potency. More than half (51.6%) reported not using personal protective equipment (PPE) during pesticide application. The study concludes that although the majority of smallholder vegetable farmers in the Kassena-Nankana Municipality had received pesticide safety training and demonstrated some awareness of pesticide-related health and environmental risks, a gap remained between their knowledge of pesticide safety and the adoption of appropriate safety practices. The study therefore, recommends continuous, participatory pesticide safety education using pictorial materials, demonstrations, local languages, and practical field exercises, alongside improved access to affordable PPE and greater engagement with agro-input dealers and regulatory institutions. Such integrated interventions could promote safer pesticide use and reduce associated health and environmental risks among vegetable farmers.

Keywords: Effectiveness, safety training, pesticide, farmers' knowledge, vegetable production

Introduction

Increase production of crops to satisfy the growing food demand has led to increased demand for pesticides for various agricultural activities such land clearing, control of pest and diseases and storage. Pesticides are utilised to produce tree crops, cereals, fruits and vegetables. According to Ansah (2019), about 87% of vegetable farmers apply pesticides to prevent and destroy pest and diseases on their farms. Ghana is known to have an increasing demand for pesticides both in quantity and types. For the period of 1995 and 2000, pesticides of 21 distinct types were imported for use in agriculture. (Lesschen, Stoorvogd, Smaling, 2004). About one-third of agricultural products in the world are produced with chemical pesticides (Tudi, 2021; Elibariki, 2017; Zhang, 2018). *Fianko et al. (2011)* reported in their research that pesticides such as Dichloro Diphenyl Trichloroethane (DDT) and 1, 2, 3, 4, 5, 6-hexachlorocyclohexane (HCH) that are not easily degradable and banned from use remain the most commonly used pesticides in emerging economies like Ghana because they are cheap, easy to synthesis or donated by developed countries. This was confirmed in a report by Northern Presbyterian Agricultural Services (NPAS, 2012) entitled “Ghana’s pesticide crisis,” attributed the increase use of fake, low-cost and adulterated pesticides in Ghana to farmers not well informed about pesticide application, dangers of exposure, lax regulatory enforcement and financial incentives.

Regardless of the importance of pesticides use in crop production, the increased and inappropriate use and handling have resulted into increased environmental and human health problems. The increase and inappropriate use of pesticides especially in vegetables farming in Ghana is a source of concern because most consumers get their vegetables directly from famers which have not been properly treated. A comprehensive study conducted in 2008 by Northern Presbyterian Services (NPAS) detected the traces of residues of pesticides in the human body (in breast milk and blood samples) of farmers. A clear indication of how dangerous pesticides can be to human health. Farmers in some instances have wrongly applied pesticides on crops which resulted in low productivity as well as affected human and environmental health (*Gerken et al., 2001*; Dinham, 2003). *Williamson et al. (2008)* established in their study that use of pesticides such as, endosulfan, lambda, chloropyfos, cyhalothrin were the cause of ill health among Ghanaian farmers. In the year 2015, it was reported that total of fifteen (15) farmers lost their lives in the Upper East region after consuming food contaminated with pesticides (NPAS, 2012). Seven people in the Northern Region died as a result of eating beans contaminated with atrazine, according to *Der et al. (2013).* A recent documentary titled '*Poison on The Menu*' by Joseph Gakpo of Joy news reveals how the increasing misuse and wrong timing of pesticides use contaminates the food we consume every day. (Joynews Doc, 2019).

A survey of Ghanaian farmers showed that a little below fifty percent of farmers had received such training by the Department of Agriculture and the rest by local NGOs (NPAS, 2012). According to Baran and Yelwa (2024), lack of training on the appropriate application of pesticides and non-adherence to good agronomic practices (GAP) exposes farmers more to the dangers of pesticide. NPAS (2012) reports that the increase rate of misuse of pesticides with the accompanying problems is because relevant stakeholders and other agencies have failed to provide the needed education, training and supervision to ensure compliance to safety in pesticide application. Training of farmers in pesticide use is especially important since research findings point that most farmers cannot read and write. Notwithstanding the risk that the misuse of pesticides poses on human health and the environment, there is limited research on how relevant and effective training received is on safe pesticide practices especially in vegetable farming (Christos, and Spyridon, 2017).

The study in this regard, seeks to examine the relevance and effectiveness of training on farmers knowledge on pesticides, behavior towards safety and pesticide application practices in vegetable farming. The findings of the research will generate information for designing relevant and effective training programs or policies on safe pesticide use for sustained vegetable production. It is also to create a platform for removing the bottlenecks in the vegetable production sector regarding the use of pesticide.

Conceptual Framework

The study employed the use of Health Belief Model (HBM). The HBM is a psychological framework used to predict and explain health behaviors by emphasising on individual attitudes, perception, and beliefs (Alamer, 2024; Alyafei, 2024). Following its development in the 1950s, the HBM suggests that the individual's tendency to engage in health behavior is determined by four major variables, namely: perceived threat (susceptibility and severity), perceived benefits and barriers, cues to action, and self-efficacy (Alyafei & Raul, 2025). According to the theory, there are six constructs that affect the probability of an individual engaging in preventative or management health practices. In particular, the HBM underlines that people assess threats associated with health and determine what actions to take based on the significance of their goal as well as the chance of reaching this goal. In this way, the HBM can be used for evaluating the efficiency of community-based programs, education and promotion practices, and prevention of chronic diseases.

In relation to the topic, the concept of pesticide safety training is the independent variable since it acts as a cue to action as well as a modifying variable. The independent variable directly increases the level of farmers' knowledge (level one outcome). Consequently, there is a series of constructs of the HBM associated with the impact of training, namely: perceived susceptibility (the probability of being exposed to pesticides), perceived severity (consequences of pesticides' use and exposure), perceived benefits (advantages of safe practices), and perceived barriers (factors preventing from following safe practices). Besides, training increases self-efficacy, contributing to people's confidence in performing safety-related practices.

All mentioned perception-based constructs mediate the influence of knowledge on behaviors related to pesticide safety practices (for example, wearing personal protective equipment, correct use of pesticides, proper storage, etc.). The role of socio-demographic variables, such as age, education, and farming experience as well as the size of the farm (the number of acres and employees), is to act as moderating variables. That is, the effectiveness of training affects knowledge and perceptions (which influence safety practices).

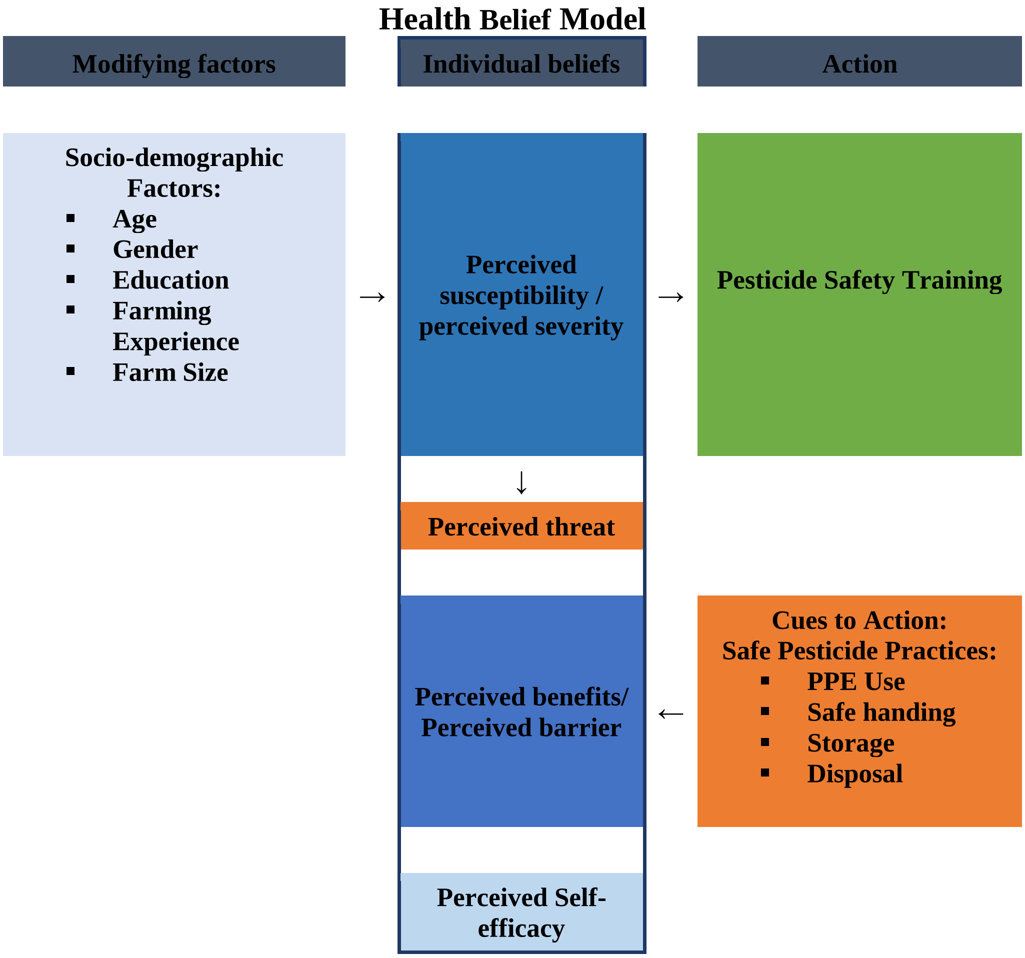


Figure 1: Conceptual framework. Source: Adapted from Sung (2021)

Methodology

Study Area

The Upper East Region has fifteen (15) districts, including Kassena-Nankana Municipality. Before the western portion of the district was divided to form Kassena-Nankana District on February 29, 2008, it was a part of the then-larger Kassena-Nankana District in 1988. As a result, the remaining portion was renamed Kassena-Nankana East District. On June 28, 2012, it was given municipal assembly status and became Kassena-Nankana Municipal District.

It is roughly located between latitudes 11°10' and 10°3' North and longitudes 10°1' West. Its political capital is Navrongo. The municipality shares boundaries with seven (7) districts and one neighbouring country. It is bounded to the north by Kassena Nankana West district and Burkina Faso, East by Bolgatanga Municipality, West by Builsa south district and Builsa North district, South by West Mamprusi Municipality. The entire land area of the municipality is 767 square kilometers. The vegetation type is Sahel and Sudan savanna covered with savanna grassland with short trees. It has a total population of 109,944 comprising 51.2% female and 48.8% male (Ghana Statistical Service [GSS], 2021). The average household size is 5.4 (GSS, 2021). The major economic sectors in the municipality include agriculture; wholesale and retail trade, including the repair of motorcycles and vehicles (9.1%); manufacturing (8.8%); education (4.1%); accommodation and food services (2.6%); and construction (1.3%). Majority (82.7%) of households depend on agriculture as livelihoods. The municipality has one of the biggest irrigation dams (Tono) for dry season cultivation of rice, maize and vegetables. Majority of the people depend on vegetable farming especially during the dry season for income and livelihood. The main vegetables grown are Pepper (Chilli), tomatoes and onions. The target population were mainly all (Commercial and smallholder) vegetable farmers in the Kassena Nankana municipality.

Sampling Procedure

Respondents for the study were selected using a multi-stage sampling technique to ensure systematic and representative coverage of the study population. This process reduces bias and allows the researcher to choose a more representative sample of the population (*Green et al., 2016*). This procedure uses a combination of sampling procedures and techniques in sampling the population. For the purpose of this research, three (3) steps were used. In the first step, the Upper East region was deliberately chosen because of the high production of vegetables. Secondly, Kasena Nankana municipality which is noted for the cultivation of vegetables was randomly chosen from the several vegetable producing districts in the Region. Purposive sampling was used to select ten (10) communities in the district who are into vegetable production and have received training. In the final stage simple random sampling technique was used to choose Ninet-five (95) vegetable producers.

Sample Size

The sample size is determine using the Slovins formula (1960) with an error of 5% and 95% confidence level as follows

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

where: n= sample size; N= total population; e = error margin

$$n=\frac{125}{1+125(0.05)^2}$$

$$n= 95$$

The researcher then sampled 95 vegetable farmers using sampling frame of 125 dry season vegetable farmers.

Data Sources

The information obtained included both primary and secondary information for analysis. The primary information was obtained by means of a questionnaire, face-to-face interviews, and key informant interviews. The secondary data was obtained from a review of documentation from MOFA, technical reports, articles, published journals and policy briefs on pesticide use among vegetable farmers.

Data Collection Tools

The data was gathered using the following research instruments; structured questionnaire, and interview guide to solicit information. Questionnaires are advantageous because they are relatively inexpensive and time-efficient, particularly when respondents provide their responses promptly. However, the use of questionnaires has some limitations. It may be difficult to verify the accuracy of information provided by respondents, particularly when the questions require participants to recall past events or report on their practices. In addition, self-administered questionnaires may be difficult to use with respondents who have limited literacy, necessitating the assistance of trained enumerators and, where necessary, translation into local languages. Such administration may introduce variations in how questions are understood and answered. Questionnaires may also limit opportunities for researchers to probe responses or obtain additional information beyond the questions included in the instrument.

The Interview guide help to elicit information with verbal questioning using a guide. Interviews enabled the researcher to obtain more detailed and comprehensive information because the interviewer could probe respondents' answers, seek clarification, and explore issues in greater depth. The opportunity to probe and clarify responses can enhance the completeness and quality of information obtained from respondents (*Knott et al., 2022*; Houtkoop-Steenstra, 1996). Interviews may also achieve relatively higher response rates than self-administered questionnaires because of the direct interaction between the interviewer and respondent. Despite these advantages, interviews have some limitations. They are relatively time-consuming and may therefore be less suitable for collecting data from a large number of respondents. In addition, interviewer behaviour, question wording, and the manner in which probing is conducted may influence respondents' answers and introduce interviewer bias (Chenail, 2011; Conrad & Schober, 2021). Poorly worded or leading questions and inappropriate probing can potentially affect the accuracy and validity of the information collected (National Center for Health Statistics, 2001). Therefore, interviewers need to be adequately trained and should use standardized, neutral questioning and non-directive probing techniques to minimize potential bias.

Data Analysis

The data was organized in excel and analyzed using Statistical Package for Social Science (SPSS) software. The data was analyzed using descriptive statistics such as frequency, percentage, mean, standard deviation. The results presented using Pie charts, Bar charts, Tables and figures.

Results and Discussions

This section presents and results and discusses the findings of the study in relation to the research objectives. It begins by describing the socio-demographic characteristics of the respondents thereby providing the contextual background for interpreting subsequent findings. Moreover, the section goes ahead to examine the types of vegetable crops grown; farmers' exposure to pesticide safety training; the knowledge farmers have about the safe use and handling of pesticides; and the way they handle pesticides with regard to mixing, application, storage, and disposal of pesticides. Whenever necessary, the analysis takes into consideration the significance of the findings in terms of pesticide safety, occupational safety, agricultural extension and sustainable vegetable crop production. The results will be compared with previous empirical studies wherever possible.

Socio-Demographic Characteristics of Farmers

It is necessary to take into consideration the socio-demographic features of farmers when trying to interpret agricultural practices, decision-making, and reactivity to interventions (*Biesheuvel et al., 2021*; Burton, 2014). In general, the socio-demographic features can include measures such as age, gender, educational attainment, number of household members, years of experience in agriculture, income, and outreach services. In the current research, the assessment of the socio-demographic features of smallholder farmers will provide some valuable information regarding how personal and household variables could shape the participation of smallholder farmers in the training on safe pesticide use practices.

The socio-demographic characteristics of the respondents are presented in Table 1. The findings indicate that the study participants comprised both male and female small-scale vegetable farmers, with males constituting the majority (57.9%), while females accounted for (42.1%). This suggests that although vegetable production in the study area is male-dominated, women were also actively engaged in small-scale vegetable farming. Similar gender patterns were reported in agricultural systems where men often dominated commercial farming activities, while women contribute substantially through labour provision, crop management, and other production-related activities (Quisumbing & Doss, 2021). Similarly, Dzobo (2016), in a survey examining self-reported symptoms associated with pesticide use among vegetable farmers, reported that the majority (74.4%) of participants were males. The relatively substantial number (42.1%) of female farmers highlights the need for pesticide safety interventions to be gender-responsive and inclusive.

With respect to age, the largest proportion of respondents (35.8%,) were between 29 and 39 years, followed by (28.4%) those aged 40–50 years and 18–28 years representing (23.8%). Farmers aged 50 years and above constituted the smallest group (12.0%). Younger and middle-aged farmers are generally more receptive to agricultural innovations and training programmes than older farmers, who may be more inclined to rely on established farming practices (Mwangi & Kariuki, 2015; Ayisi, Kozari, Kristina, 2022). Since men constitute the majority, they are likely to be the primary decision-makers and pesticide applicators, meaning training programs may predominantly reach and influence male farmers. Nonetheless, the very high rate of female engagement (42.1%) suggests that under-targeting or excluding women could severely reduce the overall efficacy of such treatments.

Regarding household membership, more than half (51.6%) of the respondents belonged to households with one to five members, while 37.9% reported household sizes of six to ten members. Only 10.5% of households had over ten people. Smaller sizes of the households might reduce the amount of family labor available for cultivation of vegetables by smallholder farmers, thereby forcing them to hire labor for pesticide application and other labor-intensive work. On the other hand, household size is an important socio-economic factor since many smallholder farmers use family labor for their agricultural practices including pesticide mixing, loading, application, and post-application activities (Damalas & Koutroubas, 2017). In consequence, both the farmers and the household members could be exposed to the dangers of pesticides as a result of participation in farm work or indirect exposure from contaminated clothes, equipment, and sprayed fields.

With regard to the educational background of the respondents, there was found to be low levels of educational attainment. While 48.4% of the respondents did not have any form of formal education, 21.1% had acquired basic education. Of the total respondents, 17.9% had obtained secondary/technical education while only 12.6% were at tertiary level of education. The results of previous research conducted by *Abimbola et al.*

(2024) and *Natukuda et al. (2014)* showed that 81.2% of the farmers had formal education. According to Karunamoorthi, Mohammed, and Wassie (2012), educated farmers are found to have high knowledge of safe usage of pesticides and can effectively read and follow the hazard warnings printed on the pesticide containers. Previous literature has shown that as compared to farmers who lack formal education, those who have formal education are found to have higher knowledge of health effects of the use of unsafe pesticides (Damalas & Koutroubas, 2016; *Jallow et al., 2017*). However, from the results of this study, it is evident that although some of the farmers received formal education, many of them (21.1%) had only primary education. Therefore, some of the farmers might lack literacy skills, and this would make it difficult for them to be able to read and understand the pesticide labels, which are mostly written in English language. Consequently, there is the need to make the labels simpler through the use of symbols and other pictures that can relay the safety message regardless of the level of literacy. Additionally, the pesticide safety training should use practical means and demonstrate in local languages.

The farm sizes from where the respondents are drawn reveal that most (51.6%) of them have farm sizes between 3 to 4 acres while 6.3% of them farm on farm sizes of 4 acres and above. This is an indication that most of the respondents are smallholder farmers. The smallholder farmers mostly depend on family labor and have few financial resources at hand, which could limit their ability to purchase appropriate protective clothing, improved pesticide spraying technology and training (Damalas & Koutroubas, 2016). This could make them vulnerable to pesticide poisoning, hence necessitating pesticide safety interventions.

Table 1: Socio- Demographic Characteristics of Farmers

Variable	Category	Frequency	Percent
Gender	Male	55	57.9
	Female	40	42.1
Age	18-28	23	23.8
	29-39	34	35.8
	40-50	27	28.4
	50+	11	12.0
Household membership	1-5	49	51.6
	6-10	36	37.9
	10+	10	10.5
Educational status	No formal education	46	48.4
	Basic	20	21.1
	Secondary/Technical	17	17.9
	Tertiary	12	12.6
Farm size	1-3	41	43.2
	3-4	49	51.6
	4+	5	6.3

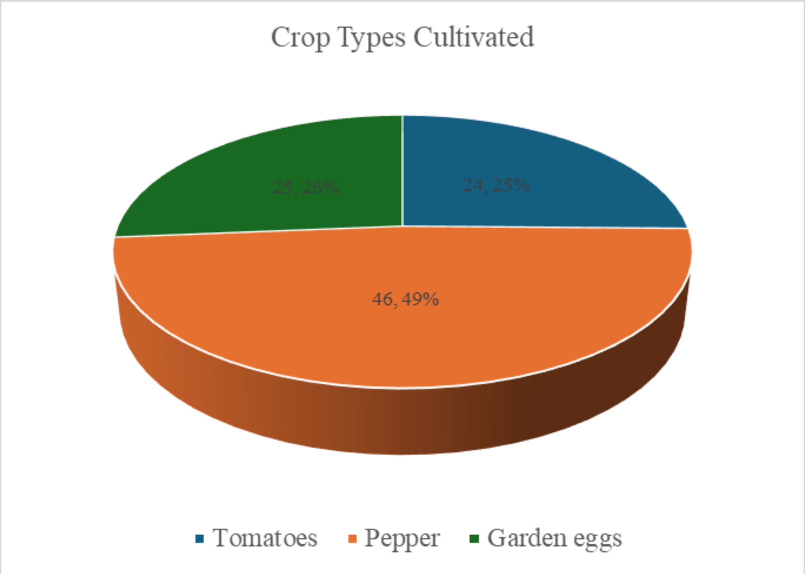
Source: The Study, 2021. Types of Vegetable Crops

An analysis of the kinds of vegetable crops that farmers grow becomes important in analyzing the level of exposure to agricultural risks. Different kinds of vegetables have different agronomic needs, pest and disease susceptibility, and dependence on chemical inputs such as pesticides (Abhilash & Singh, 2009; *Aktar et al., 2009*). In this regard, farmers' crop choice can determine their choice of pesticide, the frequency of use, and following of safety measures during application (Damalas & Koutroubas, 2016; *Lekei et al., 2014*). The identification of main kinds of vegetable crops grown by farmers becomes a crucial point in understanding farmers' behavior regarding pesticide use and the related risks associated with exposure to the chemicals (*Ngowi et al., 2007; Parsa et al., 2014*). It becomes important to know the farmers' profiles regarding their crop production in order to develop educational programs aimed at promotion of proper use of pesticides among them (Damalas, 2009; *Sharma et al., 2019*). Since vegetable crops differ in their sensitivity to pests and diseases, different amounts of pesticides are required to control them (Carvalho, 2006; *Schreinemachers et al., 2017*).

From Figure 2, the most commonly grown vegetable crop among the farmer respondents is the pepper, which constitutes 49%, while garden eggs constitute 26% and tomatoes constitute 25%. In conclusion, this implies that the production of pepper dominates the activity of vegetable farming in the study area. As such, the behavior of pesticide use among the farmers is bound to be influenced greatly by the cultivation of the peppers because of their prevalence in the farming system. The kind of vegetable crop is an important factor that influences the use of pesticides because vegetables have varying degrees of susceptibility to pests and diseases (Carvalho, 2006; *Schreinemachers et al., 2017*).

Another crop cultivated by respondents is pepper. It is a crop that is very susceptible to several pests and diseases like aphids, thrips, fruit borers, fungi and others. Repeated applications of pesticides may be required to protect the yield and quality of pepper (*Grzywacz et al., 2014*; *Nderitu et al., 2007*). This implies that farmers involved in the cultivation of pepper have higher chances of pesticide exposure because of the increased applications compared to farmers growing crops that are not demanding in pest control. Farmers growing vegetables whose cultivation involves high pest control applications, like pepper, will interact with pesticide-related information sources frequently and therefore affecting their knowledge about proper use of pesticides (Damalas & Koutroubas, 2016; *Lekei et al., 2014*). Therefore, intervention programs on pesticide safety in relation to specific crops remain very important in ensuring that farmers apply proper methods of pesticide handling and protection. Crop-specific approach to education regarding pesticides is consistent with previous research where farmers' pesticide handling was influenced by crop, pest, production intensity and number of chemical applications (*Ngowi et al., 2007*; *Schreinemachers et al., 2017*). There is enough evidence indicating that pesticide knowledge of farmers and their safe practices can be enhanced by training and extension services (Damalas & Koutroubas, 2016; *Lekei et al., 2014*).

Figure 2: Respondents and Crop Type



Source: The Study, 2021

Farmers Access to Training on Safe Application of Pesticide

Pesticide safety training emerges as an important determinant of sustainable pesticide management by farmers. Pesticide safety training helps farmers develop vital skills and knowledge on how to safely handle pesticides, how to appropriately apply and dispose of them, how to accurately determine the doses of pesticides used, use of personal protective equipment and other aspects that contribute to minimizing any negative impacts of pesticides (Damalas & Koutroubas, 2016; *Lekei et al., 2014*). Therefore, the examination of farmers' access to training programs aimed at teaching safe use of pesticides becomes very important when it comes to determining the impacts of education on pesticide-use practices. Lack of access to training services can result in the development of knowledge deficiencies, unsafe pesticide-handling practices and increased exposure levels in vegetable small-scale farmers. Effective access to training services helps farmers become more aware and comply with the safety recommendations (Damalas, 2009; *Sharma et al., 2019*). Therefore, the analysis of the farmers' exposure to the training related to pesticide safety provides many insights into the connection between the process of knowledge acquisition and the outcomes in terms of the pesticide safety. The above-mentioned statement can be proved based on findings from previous studies showing that farmers' training could have a significant impact on the increase of pesticide knowledge and influence the decisions in a safe direction (*Möhring et al., 2020; Osei et al., 2021*). For instance, *Goeb et al. (2021)* found out that the training of lead-farmers helped to boost farmers' knowledge and made them more likely to demand the use of safer pesticides despite the fact that the analysis was conducted with the use of only one source of information.

On the availability of farmer training on the safe use of pesticides, the study found that 64.2% of farmers had undergone training on pesticide safety within the last two years, while 35.8% of the farmers had not undergone any training on pesticide safety for the past two years. This is presented in Table 2. This suggests that despite the majority of farmers having undergone some level of training on pesticide safety, a considerable number of farmers did not receive any pesticide safety training. Limited access to training on pesticide safety by a considerable number of farmers increases the probability of unsafe pesticide usage such as improper mixing, dosing, the improper use of personal protective equipment, and improper disposal of pesticide bottles. Contrary to this finding, however, there is a situation in which only 38.7% of the farmers in Matabeleland North in Zimbabwe had been trained properly on the safe use, storage, and disposal of pesticides according to *Afari-Sefa et al. (2015*). Unsafe handling of pesticides was due to limited training, including improper protective measures and disposal of the pesticides.

On the training sources, most (72.1%) farmers were reported to get the pesticide safety training from the Department of Agriculture and Non-Governmental Organizations (NGOs), while 27.9% got their training from other sources. Nonetheless, it is important to think about issues such as quality of training, relevance of the issue taught, frequency of training, and means of knowledge delivery since they play an instrumental role in determining how effective the training will be. Practical and relevant training on the issue of interest is the kind that improves farmers' knowledge on pesticide safety and management practices. This is similar to what was found out by Uribe-Leitz and Ruf (2019), who observed that interventions such as training have a significant effect on farmers' knowledge and awareness of pesticide management practices.

In addition, the findings have shown that the most prevalent location where pesticide safety training was provided was the fields (54.1%), followed by demonstrations in plots (24.6%), and the MOFA premises (21.3%). The choice of field training indicates the necessity of using practical methods for the diffusion of agricultural information. Field demonstration training is considered an effective method since it helps farmers learn through experience by giving them an opportunity to understand better the application of pesticides and safety guidelines while working in a field environment (Damalas & Koutroubas, 2016; *Jors et al., 2014; Jallow et al., 2017; Schreinemachers et al., 2017*).

On the part of frequency of training received, majority (**85.2%)** of farmers reported receiving training once or twice, while only **14.8%** had received training three times. This implies that pesticide safety education may not be provided regularly enough to ensure continuous reinforcement of recommended practices. Since pesticide use decisions are influenced by changing production conditions, pest pressures, and availability of new pesticide products, periodic training and follow-up extension support are necessary to sustain safe pesticide practices among farmers (Damalas & Koutroubas, 2016).

With regard to the areas covered during training, most (60.7%) farmers received training on pesticide application, followed by the use of protective clothing (**21.3%**), disposal of pesticide containers (**13.1%**), and timing of pesticide application (**4.9%**). The emphasis on pesticide application indicates that training programmes primarily focus on technical ability of applying chemical. However, the relatively lower attention given to protective equipment use and container disposal is of concern because these aspects are essential components of reducing pesticide exposure and environmental contamination. These aspects are equally important because inadequate personal protection and improper disposal practices contribute substantially to pesticide exposure among farmers and environmental contamination (Damalas & Koutroubas, 2016; *Sharma et al., 2019*).

The results further show that **83.6%** of the respondents perceived the pesticide safety training received as relevant, indicating that the training contributed to changes in their pesticide application practices, including the use of protective equipment, appropriate timing of pesticide application, and safe disposal of pesticide containers. Some of the farmers believed that their involvement in the training program resulted in high crop productivity, meaning that there is possibility for pesticide safety training to benefit both farmers' health and productivity. This finding is consistent with previous studies indicating that farmer training programs have the ability to improve knowledge of farmers about pesticides, facilitate safe handling, and result in agricultural improvements. *MacFarlane et al. (2008*), for instance, observed greater use of personal protective equipment (PPE) by farmers after pesticide safety training, while *Mancini et al. (2009)* noted that training intervention helped to decrease number of cases of poisoning of farmers from pesticides. Matthews (2008) suggested that effective training in pesticide management can lead to increase in crop productivity as a result of better decision-making of farmers about pesticides and crop protection practices.

Nevertheless, 16.4% of the respondents considered the training to be unhelpful owing to the lack of any visible change in terms of their use of pesticides. This suggests that attendance in training programs does not always translate into a change in behavior; the success of training might depend on other aspects like the quality of training itself, the relevance of the content, frequency of follow-ups, provision of protective clothing as recommended, and the farmers' ability to apply the knowledge gained from training. This is consistent with what was found by *Feder et al. (2004)* whose study showed that attendance in Farmer Field Schools (FFS) did not necessarily bring about any improvements in the practices of farming as long as there was limited institutional and environmental support for adoption. Therefore, pesticide safety training will continue to be an important tool for improving farmers' practices; however, additional actions are needed.

Table 2: Farmers Access to Training on Safe Application of Pesticide

Variable	Category	Frequency	Percent
Received training in the last two years	Yes	61	64.2
	No	34	35.8
Source of training	Department of Agriculture / NGOs	44	72.1
	Others	17	27.9
Training location	Farmers' field	33	54.1
	Demonstration plot	15	24.6
	MOFA premises (seminar)	13	21.3
Frequency of training received	Once or twice	52	85.2
	Thrice	9	14.8
Area of training	Pesticide application	37	60.7
	Protective clothing	13	21.3
	Disposal of containers	8	13.1
	Timing of application	3	4.9
Perceived relevance of training	Relevant (changed practices, increased yield)	51	83.6
	Not relevant (no change noticed)	10	16.4

Source: The Study, 2021

Farmers' Knowledge on the Use of Pesticides

Evaluating farmers' knowledge about pesticide usage is very important since the ability to choose, handle, apply, store, and dispose of pesticides safely depends on such knowledge. Knowledge about pesticide usage is an important part of the safety of pesticides, as it forms the basis for rational decision making and may affect attitudes of farmers. In the context of this research, the evaluation of farmers' knowledge about pesticide safety was especially important for the estimation of the efficiency of pesticide safety training. Table 3 shows the distribution of respondents by knowledge about pesticide usage.

Table 3: Farmers' Knowledge on the Use of Pesticides

Variable	Category	Frequency	Percent
Knowledge on Pesticide Use	Yes No	39 56	41.1 58.9
Major pesticide used	Insecticide Fungicide Herbicide/Rodenticide	71 15 9	74.7 15.8 9.5
Awareness on Pesticides Banned by the Government	Yes No	33 62	34.7 65.3
Knowledge of the Health Effects of Pesticides	Yes No	56 39	58.9 41.1
Knowledge of the Environmental Effects of Pesticides	Loss of soil fertility Air pollution Contamination of underground water	54 39 2	56.9 41.0 2.1

Source: The Study, 2021

It is clear from the findings that most (58.9%) respondents had inadequate knowledge on pesticide usage, while 41.1% had adequate knowledge. This result shows a significant knowledge deficit among the farmers on proper usage of pesticides. With inadequate knowledge, farmers are likely to make errors on pesticide choice, dosage, misuse, storage, and disposal. The findings thus highlight the importance of increased pesticide safety education, especially for vegetable farmers. The relative low level of farmers displaying sufficient knowledge may be attributed to differences in educational attainment and availability of agricultural extension services. Other studies have also found that educational attainment of farmers can play a role in their ability to access, understand, and use information related to safety of pesticides. As an example, it was shown by *Karunamoorthi et al. (2012)* that educated farmers tended to have better understanding about the use of pesticides and how to understand the instructions provided on the pesticide labels. Similarly, *Ademola et al. (2024)* indicated that literacy levels play a role in access to information and farmers' ability to convert the information into action.

In terms of classification of pesticides, insecticides formed the largest proportion, accounting for 74.7%, while fungicides accounted for 15.8% and herbicides/rodenticides 9.5%. It should be mentioned that the predominance of use of insecticides is alarming because the excessive use and misuse of the insecticides may result in the increased exposure of farmers to dangerous chemicals. The alarming situation is that 65.3% of farmers do not have knowledge about banned pesticides by the government, and only 34.7% are aware of them. Such a low percentage of awareness is alarming because there might be a danger of farmers buying and using those pesticides that have been banned.

From the results, it can be stated that 58.9% of the respondents had information on health effects resulting from exposure to pesticides, while 41.1% did not have this information. In the case of environmental effects, 56.9% identified loss of soil fertility, 41.0% mentioned air pollution, and 2.1% identified contamination of underground water as effects of pesticide use. The interesting thing about this is that there is a clear difference between the knowledge of farmers and their practices of using pesticides. While a majority of the farmers had knowledge about the effects of pesticides on both health and the environment, this knowledge was not reflected in their practices of using pesticides. This is consistent with the findings of Ousterlund et al. (2014) in a knowledge, attitude, practice (KAP) study done in Uganda where it was found that farmers could have a lot of knowledge about the health effects of pesticides yet practice unsafe pesticide use.

Knowledge-Attitude-Practice (KAP) framework, which recognizes that knowledge is an essential precursor to changing behavior but does not necessarily lead to correct practices could be considered for this study. Although farmers are aware of the dangers associated with pesticide use, they may still practice inappropriately because of economic reasons, lack of access to personal protective equipment (PPE), lack of availability of safer pesticides, ease, habit, or lack of practical skills. The same point was made by Matthews (2008) who emphasized the need for practical and situational responses to pesticide safety and not only information about the matter. These results may also be understood from the perspective of the Health Belief Model (HBM). Under this model, mere knowledge of health risk does not lead to behavior change if the person does not feel that he/she is susceptible to the risk; finds the threat serious; thinks that the suggested preventive measure is useful, and the barriers to undertaking the prevention are not significant. Thus, although farmers may be aware that pesticides have negative health consequences, they may not feel personally vulnerable enough to use personal protective equipment (PPE) or follow other safety measures.

Farmers' Practices Related to Safe Pesticide Use

The farmers' pesticide application behaviors constitute an important metric regarding the link between awareness and actual safe behaviors. The examination of pesticide choice, sources of pesticides, use of PPEs, and obstacles to wearing PPEs provides insights into the factors that influence the farmers' pesticide exposure. This is because there is no automatic association between hazard awareness and compliance with safety recommendations. Table 4 presents the farmers' behavior in terms of safe pesticide use.

Table 4: Farmers Behavioural Practices in Safe Pesticide Use

Variable	Category	Frequency	Percent
Factors influencing choice of pesticide	Price of product	45	47.4
	Potency of pesticide	30	31.6
	Recommendation by someone	20	21.1
Source of pesticide purchase	Agro-input dealers	82	86.3
	Open market	13	13.7
Usage of personal protective equipment (PPE)	Yes	46	48.4
	No	49	51.6
Type of personal protective equipment (PPE) used	Overall	20	21.1
	Gloves	19	20.0
	Face mask	6	6.3
	Goggles, boots, trousers, respirator	1	1.1
Reasons for non-use of PPE	Financial constraints	29	30.5
	Uncomfortable to use	13	13.7
	Not considered necessary	7	7.4

Source: The Study, 2021

The results suggest that economic factors are the most commonly mentioned factors influencing the choice of pesticide used. In particular, 47.4% of those surveyed mentioned the price of the pesticide as an influencing factor, 31.6% thought that the effectiveness of the pesticide was important, and 21.1% followed recommendations from someone else. This means that the importance of price can affect farmers' decisions concerning the choice of the pesticide because it is more economically beneficial. It has significant consequences for the safety of pesticides because economic factors can cause farmers to choose a pesticide based on its price and not on its efficacy.

The results differ from the emphasis of Plianbangchang, Jetiyanon, Wittaya-Arekul (2009), who reported that pesticide selection should primarily be guided by the pest or disease affecting the crop. The difference may reflect variations in farmers' access to technical information and reliable advice on pesticide selection. In the present study, the fact that only (31.6%) of respondents identified pesticide potency as a factor and that (21.1%) relied on recommendations from other individuals suggests that technical considerations may not consistently guide pesticide-selection decisions. However, the finding should not be interpreted as evidence that farmers purchased counterfeit or highly toxic pesticides, since the study did not directly assess the authenticity or toxicity of the products used.

The source of pesticide purchase provides an additional perspective on farmers' pesticide-use behaviour. A large majority (86.3%) of respondents reported purchasing pesticides from agro-input dealers, compared with (13.7%) who purchased them from open markets. The dominance of agro-input dealers may provide an opportunity for strengthening pesticide safety interventions because these outlets can serve as important points for disseminating information on appropriate pesticide selection, dosage, application procedures, and safety precautions. However, the effectiveness of this approach depends on the knowledge and capacity of agro-input dealers to provide accurate and responsible guidance. Strengthening collaboration between agricultural extension personnel, regulatory authorities, and agro-input dealers could therefore improve the quality of pesticide-related information available to farmers at the point of purchase.

With respect to the use of personal protective equipment (PPE), slightly more than half (51.6%) of the respondents reported that they did not use PPE when applying pesticides, whereas (48.4%) indicated that they used PPE. This finding indicates that slightly more than half of the farmers were not consistently adopting this important protective measure. The relatively low level of PPE use is concerning because direct contact with pesticide formulations during mixing, loading, and application can increase the risk of occupational exposure. The finding also demonstrates that awareness of pesticide-related health effects, reported by (58.9%) of respondents in Table 3, did not necessarily translate into the adoption of protective behaviour. This knowledge–practice gap is an important finding of the study.

Among farmers who reported using PPE, overalls were the most (21.1%) commonly reported protective item followed, by gloves (20.0%) and face masks (6.3%). Only 1.1% of the respondents claimed to use goggles, boots, trousers, and respirator at the same time. The trend observed shows that use of PPE was partial, since very few farmers used the complete set of PPEs. Though use of different pieces of PPE can offer some level of safety, it does not guarantee complete reduction of exposure through all possible modes. Keifer (2000) pointed out that proper use of PPE, together with other precautions and proper personal hygiene, can effectively minimize exposure to pesticides and poisoning from them. The findings therefore point not only to a need to increase PPE adoption but also to improve farmers' understanding of the appropriate types and combinations of protective equipment required during different pesticide-handling activities.

Financial constraints were the most frequently reported reason for not using PPE. Specifically, (30.5%) of the respondents identified financial limitations, while (13.7%) considered PPE uncomfortable and 7.4% did not consider PPE necessary. These findings indicate that non-adoption of PPE is influenced by both structural and behavioural factors. The prominence of financial constraints suggests that simply educating farmers about the importance of PPE may not be sufficient if appropriate protective equipment is unaffordable or difficult to obtain. Similarly, perceptions of discomfort may discourage farmers from using protective equipment, particularly under hot field conditions. The proportion who did not consider PPE necessary also suggests that some farmers may underestimate their susceptibility to pesticide exposure despite being aware of its potential health effects.

All in all, there appears to be an evident difference between the understanding of the potential risks of pesticides and compliance with the prescribed precautionary measures. The choice of pesticides by farmers was mostly based on their cost, and more than half of the participants did not use any personal protective equipment while applying them. In addition, when it came to using such equipment, the use of protective means appeared to be restricted only to single items rather than covering everything that was needed. These findings support the idea that the behavior related to pesticide safety involves not only knowledge.

This result fits the Knowledge-Attitude-Practice model because while knowledge acts as the base for safe practice, it does not necessarily ensure safe practice. However, the findings could be seen using the Health Belief Model, focusing on perceived susceptibility and perceived barriers. Farmers who perceive themselves to be at considerable risk of being affected by pesticides may be willing to use PPEs. On the other hand, farmers who think they are at little risk or who consider the PPEs expensive and uncomfortable may not want to use the PPEs. Therefore, intervention strategies aimed at promoting safe practice in relation to pesticides need to take care of both these issues.

Conclusion

From the research findings, it is clear that there are certain gaps in relation to the safe application of pesticides by the vegetable farmers in the Kassena-Nankana municipality. Some of the farmers exhibited certain awareness in regard to the dangers posed by the use of pesticides both on the health front and in the environment, while others had certain gaps in terms of their knowledge about pesticides and the environment in general. There exists a clear disparity between knowledge and practice. The decisions made by the farmers on choice of pesticides were mainly influenced by economic reasons like cost of the pesticide products while more than half of the participants indicated that they do not use personal protective equipment (PPEs) when applying pesticides. Economic limitations, discomfort, and the belief that PPEs are unnecessary have been cited as major obstacles for the use of PPEs. All these suggest that there exist many other factors that influence hazardous use of pesticides.

Also, it is evident that there are benefits of pesticide safety training in terms of safety practices among farmers. Therefore, there is a need to improve the effectiveness of training programs that go beyond just providing information by including demonstrations on the right way of choosing the type of pesticides, their doses, proper application, storage and disposal of pesticides, as well as PPE.

Recommendation

Based on the findings of the study, the following recommendations are proposed:

1. It would be important to strengthen pesticide safety education and certification programmes. The Ministry of Food and Agriculture (MoFA), through agricultural extension services and relevant stakeholders should invest in the design and implementation of education and certification programs on pesticide safety for farmers so as to raise farmers' awareness about pesticides and risks related to their use. Training should also demonstrate the correct selection, use, maintenance, and storage of PPE and explain the health consequences of inadequate protection.
2. It is recommended to adopt participatory and accessible risk-communication approaches (e.g. pictorial materials, demonstrations, symbols, practical field exercises, and communication) in local languages that are appropriate for farmers with limited literacy.
3. It would be essential to adopt a more integrated approach to improving pesticide safety practices. Interventions should address the multiple factors influencing farmers' pesticide-use behaviour rather than focusing solely on knowledge provision. Agricultural policies and programmes should integrate continuous training, agricultural extension support, behavioural-change strategies, and measures that address economic barriers to safe pesticide use. Particular attention should be given to helping farmers make pesticide-selection decisions based on pest and disease conditions, recommended products, safety considerations, and appropriate application requirements rather than price alone.
4. Government agencies, farmer groups, agro-input dealers and development partners need to explore means through which farmers will have increased access to low-cost, proper and user-friendly PPEs. These include subsidies on PPEs, group buying systems or partnering with farmer groups as means to address the cost barrier. Training on correct selection, handling, maintenance and storage of PPEs and implications for farmers' health when not using appropriate PPEs needs to be included in the training programs.
5. Given that a large proportion of farmers in this study get their pesticides from agro-input dealers, regulatory and extension agencies

need to improve the ability of these dealers to give farmers accurate information on how to choose and handle the pesticides. The dealers need to promote only approved pesticides and shun the promotion of those that are banned or restricted.

6. Regulators of the use of these chemicals need to increase monitoring and supervision of the distribution and use of pesticides in vegetable-growing communities. Information on banned and restricted pesticides needs to be available to the farmers whereas dealers need to be supervised in order to reduce the availability of such products.

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Human Research Statement

For this research, no ethical clearance was required because of the low-risk nature of the investigation, which did not involve clinical procedures and treatments but involved voluntary interviews and surveys. Nonetheless, this research always complied with the ethical principles of informed consent, confidentiality, and anonymity.

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