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Assessing Vegetable Farmers' Knowledge of Disease and Pests Control Methods in Ghana: A Survey of Tomato (*Solanum lycopersicum* [L]) Farmers in the Mampong Municipality of the Ashanti Region of Ghana

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ABSTRACT

A survey of 200 farmers in the Mampong Municipality in the Ashanti region was conducted between June and October 2016. It was to determine their knowledge of different pests and disease control methods employed, access to extension services, pesticides use and other pests control methods. The study relied on data collected from respondents, 12 key informants (pesticides dealers, vegetable buyers and local chief farmers), field surveillance and observation as well as the reports of the Directorate of Agriculture in the Municipality. Data were captured and analyzed using MS Excel and Statistical Package for Social Sciences (SPPS) version 16 (SPSS Inc., Chicago, IL) and interpreted into simple percentages on tables and charts. The result showed that farmers are above 20 years and 18% were female. The majority (74%) have at least basic education with six (6) or more years' of experience in tomato production. Sixty-four percent (64%) had no access to extension services due to poor contact with the agricultural extension agents (AEAs). Most respondents (70%) lacked education on pesticides and alternative (e.g., integrated pests' management) control. Nine-two percent acknowledged the dangers of pesticides to public health. Sixty-four percent practice bi-weekly calendar spraying while 30 % and 6% practice weekly and occasional spraying respectively. Forty-four percent of farmers throw used containers or leave them on the farm. More education is needed to ensure safe use of pesticides and wholesome tomatoes for the public.

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Introduction

Vegetable production is a traditional activity among Ghanaian farmers. There are several indigenous vegetables such as tomato (*Solanum lycopersicum* [L]), okro (*Abelmoschus esculentus*), ayoyo (*Corchorus sp*), waterleaf (*Tilanum triangulare*), alefo (*Amaranthus sp),* roselle (*Hibiscus sabdarifa*), gboma (*Solanum macrocarpon*), garden egg (*Solanum melongena),* etc., which are used for home consumption. Before the introduction of the exotic vegetables such as cabbage (*Brassica oleracea* var *capitata*), lettuce (*Lactuca sativa*), spring onion (*Allium tricuum*), sweet pepper (*Capsicum anuum*), carrots (*Daucus carota*), etc. local vegetables were also produced for sale at various local markets for income.

Agriculture contributes about 20% of Ghana's Gross Domestic Product (GDP) with 35% of total employment coupled with rising agricultural productivity that contributes to higher agricultural wages, and thus to poverty reduction, especially in rural regions, (Memuna et al., 2015; IMF, 2019; Ghana Statistical Service, 2019). Many farmers especially the youth are engaged in vegetable production such as sweet pepper, tomato, onion, garden eggs, cabbages, carrots, hot pepper, chilli, lettuce, etc. Large-scale vegetable production for export to the European Union (EU) is practised mainly in the southern parts of the country especially the Accra plains, Weija area and some other coastal regions. The bulk of Ghana's vegetables are mostly produced by smallholder farmers with no or little formal education and less food safety knowledge but several years in the business were likely to produced unsafe vegetables compared to other farmers with some level of education (Quansah, et al., 2020). Vegetable production in the northern parts of the country is under irrigation during the dry season for local consumption, while the forest zone (middle belt of Ghana)

produces vegetables mostly during the rainy season and in some areas during the dry season along water bodies for the urban populations (Sinnadurai, 1991; Chagomaka et al., 2015; Nchanji et al., 2017; Chagomaka et al., 2018).

The production and consumption of vegetables contribute to improving the nutrition of the population by providing carbohydrates, vitamins, mineral salts, proteins, fats, antioxidants as well as phytochemicals to protect people from non-communicable disease (Yang and Keding, 2009). Some vegetables serve medicinal purposes such as the traditional use of garlic for lowering blood pressure, cholesterol and glucose concentration and reduction in the risk of prostate cancer (Tsai et al., 2012; Zhou et al., 2013; Baya et al., 2014), and the African eggplant as a cheap and natural anti-ulcer remedy (Chioma et al., 2011). It is also a known fact that tomato is used in almost every home in most dishes in Ghana and has a good market potential in every part of the country. In 2016, tomato contributed GHC294, 449.94 million of household income in the forest area alone (Ghana Statistical Service, 2019). The emergence of supermarkets and high-level hotels and restaurants in urban and peri-urban areas has created an enormous opportunity for increased vegetable production to feed a rapidly increasing middle-class with the quest for healthy eating.

Vegetable production (local and exotic) all over the country apart from meeting the food needs of the people also serve as an income-generating activity for many, especially the unemployed. Despite the importance of this enterprise in the agriculture sector of the Ghanaian economy, the problems it creates in respect of pesticide use in pests control management practices cannot be underestimated. Farmers including tomato farmers are misusing pesticides by spraying too close to harvest (thus contaminating the crop before it is consumed), over-applying the dosage, applying pesticides intended for cash crops to growing food crops or applying pesticides intended for growing crops on stored crops, using obsolete or expired pesticides and mixing different chemical pesticides to have a cocktail that is so potent (Northern Presbyterian Agriculture Services, 2012; Memuna et al. 2015; Afari-Sefa et al., 2015; Amoako et al., 2012; Donkor et al., 2016; Nchanji et al., 2018).

According to Fianko et al. (2011), the number of pesticides imported into the country from 2002 to 2006 increased from 7763 metric tons to 27,886 metric tons. In 2011, Ghana spent over 370 million US dollars on pesticides imports into the country (Food and Agricultural Organization, 2010). The Ghana Statistical Service (2019) indicates that, in 2016 about 1.2 million households purchased herbicides for the farm while one million households purchased insecticides for field activities amounting to GHC16,544.54 million and GHC288.49 million respectively.

Consequently, there have been several mass media reports in recent times of frequent chemical poisoning of farmers and consumers of vegetables in several parts of the country leading to several health challenges such as impotence in men and infertility in women due to the inappropriate use of these pesticides by farmers possibly due to insufficient knowledge of the use of these chemicals (NPAS, 2012; Issahaku, 2012; Asante et al., 2013; Afari-Sefa et al., 2015; Memuna et al., 2015). On the global front, approximately 385 million annual cases of unintentional acute pesticides poisoning (UAPP) are reported with 11,000 fatalities (Boeder, et al., 2020). They indicated that, based on a worldwide farming population of approximately 860 million, about 44% of farmers are poisoned by pesticides every year with the greatest estimated number of UAPP cases. A report by Ghana News Agency (GNA) on 5th October (2015), indicated that the export of vegetables from Ghana to the EU suffered serious challenges in respect of the quality and safety of these vegetables and therefore imposed a temporary ban/freeze of some vegetables and fruits based on sanitary and phyto-sanitary-bacterial contaminants and pesticides. Therefore, concerns have been raised by environmentalists and agriculturalists on the increasing poisoning of farmers and the long-term effects of pesticides on the aquatic and terrestrial ecosystems.

Most of the local tomato varieties cultivated in Ghana are poor in colour, watery, acidic and have a shorter shelf life, making tomato production unprofitable and so some commercial farmers mostly rely on imported (seed) varieties for their high textural qualities (Asante et al., 2020; Melodey et al., 2019). These varieties are however not resistant to local pests and diseases and require rigorous pests and disease control measures. Many farmers rely solely on chemical pest control instead of alternative or integrated pests control methods as over 87 % of Ghanaian vegetable farmers use pesticides (Manu, et al., 2021; Fianko et al., 2011; Amoah et al., 2006). The tomato fruit borer (*Helicoverpa armigera*) has been identified as one of the most serious pests of tomato in Ghana (Youdeowei, 2002; PAN-UK, 2002). It is considered notorious due to its polyphagous nature of having a wide range of alternate hosts such as cabbage, tomato, pigeon pea, and chili (Faqiri, 2016). Unconfirmed reports suggest that though farmers have increased the number of sprays and sometimes the chemical concentrations, the pest (*Helicoverpa amigera)* and leaf spot (*Cercospora sp*) are not effectively controlled as desired.

In Ghana, there is a paradigm shift in the eating habit among the populace especially the middle class where the need to consume more vegetables is fast catching up leading to imports of various vegetables from the Netherlands, South Africa, China and neighbouring countries such as Burkina Faso, Mali and La Cote d'Ivoire (Asante, et al., 2020; Asante et al., 2013). Ghana produces 380 000MT of tomatoes each year and consumes about 480 000MT with deficit being imports from neighbours (Agyenim Boateng, 2021; Asante, et al., 2020; Asante et al., 2013). The country also imports between 109, 513 MT and 120,000MT of processed tomatoes from Europe each year, according to the Chamber of Agribusiness Ghana (FAO STATS, 2013; Agyenim Boateng, 2021). It is against this background that local farmers are doing everything possible to increase production by reducing crop losses to pests both at pre-harvest and post-harvest levels. The use of agrochemicals/pesticides in developing countries including Ghana is said to be on the ascendancy even though it is relatively small compared to developed countries (Duwiejuah, et al., 2019; Demi and Sicchia, 2021). There is however, no published reports on farmers' knowledge of tomato pest control methods in the municipality as vegetable /tomato farming is fast becoming an economic venture that employs many and especially the youth.

The objectives of the study are:

- To assess farmers' knowledge of different types of pests and disease control methods
- To determine whether farmers have access to adequate extension services on various types of pests and disease control methods.
- To determine the most adopted pests control method employed by farmers in the area.

Materials and methods

Description of the study area

The study was conducted in the Mampong Municipality from June 2016 to September; 2016. The Mampong Municipality was split and upgraded from the former Sekyere West District into Mampong Municipal and Sekyere Central District by Legislative Instrument (L.I.) 1908 (Fig. 1). It is one of the 43 administrative capitals in the Ashanti Region. It is bounded to the south by Sekyere South district, to the east by Sekyere Central and to the North by Ejura Sekye Dumasi districts. The capital for the Municipality is Asante-Mampong located within longitudes 0° 05''W and 1° 30'' W and latitudes 6° '55''N and 7° 30''N with a total area of about 23.9km^2. It has a population of 88,051 with an annual growth rate of 1.3% according to the 2010 PHC (Ghana Statistical Service, 2014).

It lies within the Wet Semi-equatorial zone with a bimodal rainfall pattern between March and October with a mean annual rainfall of between 1200 and 1500mm (Hall and Swaine, 1981). There is a short period of drought between December and March marked by the northeasterly winds (harmattan). The average temperature is about 27°C with variations in mean monthlies ranging between plus three to minus five degrees Celsius (+3°C to -5°C) throughout the year. The vegetation of the area has been reduced from its original Moist Semi- Deciduous Forest in most areas to secondary forest as a result of human activities like tree felling, charcoal production and farming. The Municipality is fairly drained by streams and rivers such as the Afram, Kyeremfa and Sasebonso. It exhibits five major soil types according to the Food and Agriculture Organization (FAO) system of classification (Sekyere West District Assembly, 2005). These are the Budewa-Sutawa Association, Ejura-Denteso Association, Nyankpala-Kpelesawgu-Volta Association, Denteso-Sene Association and Dukusen-Bremba Association. The major economic activity is farming, trading and formal employment. With respect to farming the major crops grown in the area are maize (corn), yam, cassava, rice, plantain, cocoyam and vegetables such as tomato, garden eggs, hot and sweet pepper, cabbage, carrots, etc. in areas suitable for these crops.

Selection of communities and interviews with farmers

Sampling sites were in vegetable production parts of the district and determined by use of multi-location purposive sampling. Tomato production is not done in all parts of the district as different soil types are suitable for different crops. Five of the seven communities noted for tomato production were purposively selected. These are Bunuso, Kofiase, Mprim, Adiidwan and Benim. Forty (40) farmers were randomly selected in each community making a total of two hundred (200) farmers. Tools used to obtain information about farmers' knowledge related to tomato pests and disease control methods were semi-structured questionnaires after pretesting was done. All the 200 respondents were interviewed individually at their homes in the local language (Twi).

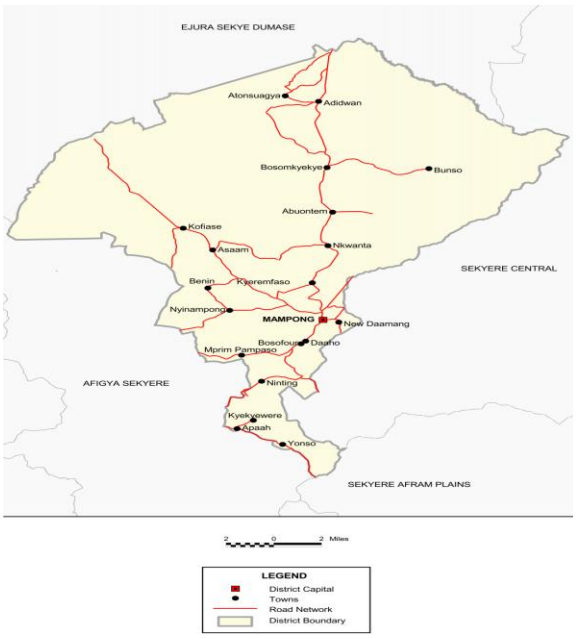

Figure 1. Map of Mampong Municipality
Source: GSS, 2014

Interview with key informants

An interview guide was prepared and used to ensure that all required information was obtained during the interviews. It was conducted on two main groups of stakeholders: opinion leaders and chemical sellers. Twenty key informants (four from each community) were randomly interviewed to gain an insight into the use of pesticides in pests control to triangulate (i.e. getting information from different sources through enquiries, observations, etc. and comparing the information to ensure its reliability) the information obtained from farmers. In most cases the key informants were within the tomato value chain including farmers, drivers, agrochemical/input sellers, market women into tomato buying at the farm level and some, few spraying gang members (a group of young men trained by the government for cocoa pests control but are hired to spray other crops in times of need by farmers). This interview style was used as it relies primarily on the spontaneous generations in the natural flow of an interaction (Cook, 2002).

Secondary data

Secondary data at the District Agriculture Directorate was reviewed to assess the type of pesticides supplied to the farmers in recent years during cropping seasons. The information gathered also included special programmes aimed at providing knowledge to farmers with regards to pests control. In addition, the eight major agrochemical shops at Mampong, Benim, Adidwan and Kofiase were contacted to obtain data on the pesticides sold to farmers, those patronized by farmers and how they (dealers) assist the farmers in acquiring knowledge on pesticide use.

Data analysis

Data were processed and subjected to Microsoft Excel (2010 version) and Statistical Package for Social Sciences (SPSS 16 version). Qualitative information from questionnaires was also used to supplement useful statistical outcomes. Apart from word format presentation, tables and charts were generated by the softwares and presented in the results.

Results

Socio-demography of respondents.

The study revealed that people under 20 years old were not engaged in tomato production. People dominating this activity were above 40 years and made up of 40% of the respondents followed by 31-40 years' group as in Table 1. It was also established that only 18% of the respondents were female as against 82% for their male counterparts. In terms of educational level of the farmers interviewed, only 26% of them had no schooling while a total of 74% had basic, secondary and tertiary education. The study revealed that 66% of the respondents had 6 or more years of experience in vegetable production.

Respondents' access to knowledge and information

The study revealed that only 36% of the tomato farmers claimed to have access to extension services while 64% claimed they did not have access (Table 2). On the frequency of contacts with the Agriculture Extension Agent (AEA), responses varied from weekly to monthly. It showed that 18% of the respondents had fortnightly contacts, while weekly and monthly contacts recorded 10% and 8% respectively, while those without extension was made up of 64%.

When asked whether they felt they had adequate extension education, especially with respect to pests control and pesticides use, 30% responded in the affirmative while 70% responded in the negative as in Figure 2. The respondents (70%) claimed they got information from other farmers and parents whom they worked with for some time before going on their own. Thirty percent (30%) of the respondents had had interaction with the defunct Ghana Organic Agriculture Network (GOAN) in the past through their AEAs in the use of neem extract as pesticide.

Table 1. Socio-demographic Characteristics of Respondents

	No. of respondents	Percent (%)
Age range (Years)		
20-30	48	24.0
31-40	72	36.0
Above 40	80	40.0
Total	200	100
Sex		
Male	164	82
Female	36	18
Total	200	100.0
Level of education of respondents		
No schooling	52	26.0
Basic school	80	40.0
Secondary	56	28.0
Tertiary	12	6.0
Total	200	100.0
Years of experience of respondents		
1-5	68	34.0
6-10	96	48.0
10 +	36	18.0
Total	200	100.0

Source: Field survey, 2016

Table 2. Respondents' Access to Extension Service

	No. of respondents	Percentage (%)
Accessibility to extension		
Yes	72	36.0
No	128	64.0
Total	200	100.0
Frequency of contact to AEA		
Weekly	20	10.0
Fortnightly	36	18.0
Monthly	16	8.0
No Extension service	128	64.0
Total	200	100.0

Source: Field survey, 2016

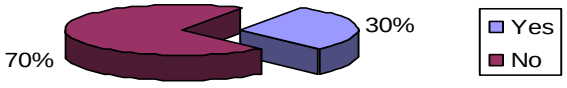

Figure 2. Farmers' response to adequacy of education on pests control and pesticides use
Source: Field survey, 2016

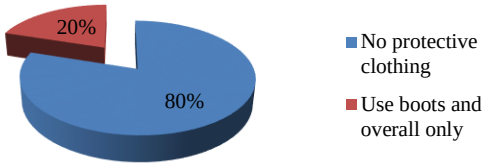

Figure 3. Use and non-use of protective equipment by farmers during spraying
Source: Field survey, 2016

Table 3. Type of Spraying Machine Used and Frequency of Spraying

	No. of respondents	Percent (%)
Spraying machine		
Knapsack	200	100.0
Mist blower	0	0.0
Total	200	100.00
Frequency of spraying		
Weekly	128	64.0
Fortnightly	62	30.0
Occasionally	12	6.0
Total	200	100.0
Pests control method		
Chemical	200	100
Manual	0	0.0
Alternative method (IPM)	0	0.0
Total	200	100.0

Source: Field survey, 2016

Precautionary measures before, during and after pesticides use.

It was established during the field observation and the questionnaire interview that over 80% of the farmers did not use the appropriate gear for their spraying exercises either due to ignorance or lack of resources to purchase them (Figure 3). Only 20% of the respondents wore boots, caps and overalls, while all farmers interviewed said they did not use respirators/nose masks, gloves and goggles during spraying. Handkerchiefs were used as improvised respirators during spraying and eating or smoking was not done when spraying. All respondents washed themselves and the spraying machine with soap after the exercise. Personal interaction with the farmers also showed that they did not observe the wind direction and also sprayed any time of the day provided it was not raining.

Frequency of use of chemical pesticides

The results showed that the knapsack was the sprayer used by all respondents (100 %) in pest control (Table 3). It further showed that all the respondents practiced calendar spraying of weekly (64 %) and fortnightly (30 %). In respect of alternative pests control measures, it was established that all respondents (100 %) depended mainly on chemicals to control insect pests, though some were taught how to use neem extract. The manual use of hand and/ hoe to uproot/weed under the crops is also a common practice among the respondents

Respondents' personal experience of the dangers of pesticides use

All the respondents (100%) according to the study claimed they knew or had had experience about the effects of pesticides on public health. They mentioned some dangers associated with its use such as dizziness, death or sickness if poisoned. Those who had experienced some form of poisoning testified to the agony they went through. (Fig 4a). Examples of death through self-poisoning (suicide) were mentioned in a couple of times. In terms of the effects of pesticides on crops, almost all the respondents acknowledged some effects they had ever observed such as burning/scotching of crops. They also talked of the drift of chemicals on nearby crops and residual effects of some chemicals on certain crops.

Regarding the environment, 82% of the respondents said they had heard on the mass media such as the television and radio that chemicals were polluting certain water bodies in some parts of the country especially around the mining communities, but had not heard much on agrochemical polluting the environment (Figure 4b). Eighteen percent however, indicated they read about chemicals effect on the environment.

Common disposal methods of empty containers

The old practice among vegetable farmers including tomato farmers in Ghana where empty containers after use were thrown away, reused, etc. was confirmed by this study with startling scenes in the study area. Forty-four percent (44%) of respondents said they threw containers away or left them on the farm for other farmers to see. They claimed the practice helped them in information sharing on the chemicals they use, while the rest buried or burnt them (Figure.5)

Chemical poisoning among tomato farmers in the study area

The study results and information from informants showed that the majority of tomato farmers and other farmers who use agrochemicals especially insecticides as the order of the day; had experienced some kind of poisoning. They said symptoms ranged from dizziness, headache, and in some serious cases vomiting and collapse of the applicant/user. Figure 6 indicates that 84% of the respondents experienced occasional poisoning at one time or the other during application while eight percent (8%) experienced poisoning very often. This is attributed to worn out parts of the spraying machine thereby causing leakage and inhaling of the spray (chemical mixture). It was also detected that most of the respondents did not consider the wind direction before undertaking any spraying activity. Therefore, when they are moving against the wind, they unconsciously inhale the spray and by the time they complete the exercise they had taken in a lot of the chemical.

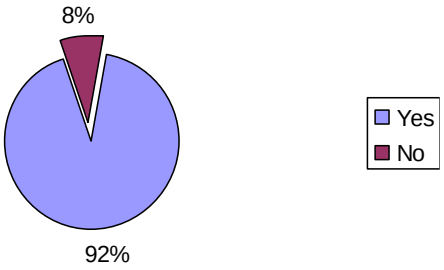

Figure 4a. Respondents' experience of chemical poisoning
Source: Field survey, 2016

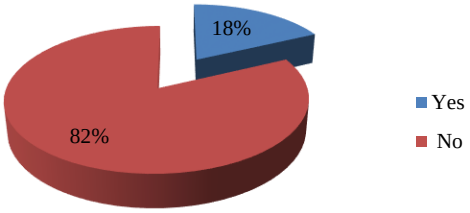

Figure 4b. Respondents' awareness of pesticides effects on the environment
Source: Field survey, 2016

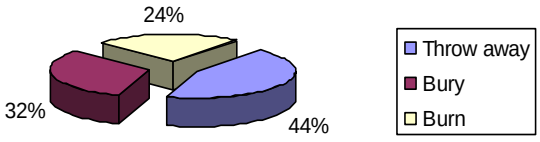

Figure 5. Respondents' disposal methods of empty containers
Source: Field survey, 2016

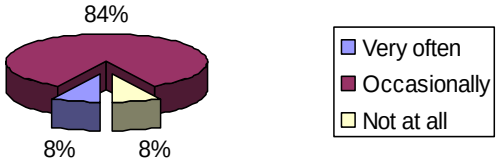

Figure 6. Respondents' frequency of chemical poisoning
Source: Field survey, 2016

Table 4. Farmers' Knowledge and Practice of Integrated Pests Management (IPM)

	No. of respondents	Percentage (%)
Knowledge of IPM		
Yes	10	5.0
No	190	95.0
Total	200	100.0
Practice of IPM		
Yes	0	0.0
No	200	100.0
Total	200	100.0

Source: Field survey, 2016

Farmers' knowledge and practice of IPM

The interview showed that only 5 % of the respondents had heard of Integrated Pests Management (IPM) and attended a workshop on the use of biological pesticides. The rest of the farmers (90%) had not heard of it and did not have any knowledge on IPM (Table 4). On the practice of IPM as an alternative pests control measure the results showed that no farmer among those interviewed practiced it on commercial scale.

Pests control methods used by farmers

Personal field visits to some sampled tomato farms in the five villages were made to cross-check the findings produced from the semi-structured interview. The field visits showed that all the tomato farmers relied solely on chemical pesticides (insecticides and fungicides) in controlling insect pests and diseases.

Observation of safe/re-entry periods before harvest

Safety periods observation among vegetable farmers is a huge problem in the country according to several reports (Wandaat and Kugbe, 2015; NPAS, 2012; Ackerson & Awuah, 2010). It was realized that the re-entry (safety) period after spraying by tomato farmers prior to harvest varied from five (5) days to two weeks (Figure.7). There are reports that some farmers out of the desire for money would harvest after two to three days of spraying especially during the lean season where there is a very high demand for vegetables including tomatoes (Wandaat and Kugbe, 2015; NPAS, 2012). It is also believed that farmers out of fear would tell any interviewer that the last spray was 10 days ago, because some of them adopt calendar spraying of every 3-10 days and could spray as many as times as possible as reported by Osei et al. (2013) and Amoako et al. (2012).

Farmers' Information Sources and Frequency of Contact

The survey showed that the extension services is the second least source respondents get information from. The source of information that respondents often rely on is from other farmers (40 %) while the official source (extension services is only 16 % (Table 5).

Government's interventions in building capacities of farmers

There is a well-organized research institution (the CSIR) mandated to generate agriculture technologies and information for well-structured unified extension services fully funded by the central government Research-Extension Linkage Committees (RELCs), a body comprising research, extension and farmers exist in all the 16 regional capitals of Ghana to build capacities and provide backstopping to agricultural extension officers.

The Agriculture Sub Sector Improvement Programme (AgSSIP) and the West Africa Agriculture Productivity Programme (WAAPP), both World Bank-funded programmes from 2002 to 2016 and recently the modernizing agriculture in Ghana (MAG), a Canadian Government-funded programme since 2017 contributed to building the capacities of extension officers and farmers.

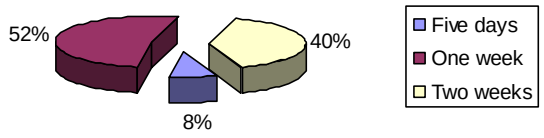

Figure 7. Respondents' observation of safety periods prior to harvest
Source: Field survey, 2016

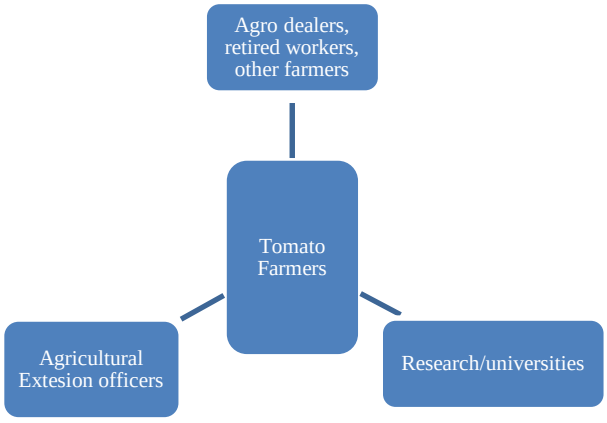

Figure 8. Information flow to tomato farmers in the study area
Source: Field survey, 2016

Table 5. Sources of information and frequency of contact of respondents

SI	FC	NR	%
Extension services	O	32	16.0
Chemical sellers	O	60	30.0
Neigbhours/other farmers	V	80	40.0
Retired workers/family members	V	28	14.0
Total	-	200	100.0

SI: Source of information; FC: Frequency of contact; NR: No. of respondents; O: Occasionally; V: Very often; Source: Field survey, 2016

The Planting for Food and Jobs under the Modernizing Agriculture in Ghana (MAG) programme has strongly supported agriculture knowledge generation (research) and extension delivery in all aspects of agriculture including vegetables. More extension workers were recruited in 2017 that improved the extension officer: farmer ratio that was 1:1500 in previous years. Logistics such as motor-bikes, pick-ups as well as traveling and transport allowances are provided to enhance knowledge and information sharing.

The effects of the enhanced logistics supply for the agricultural extension service delivery increased the annual outputs of some of the targeted crops such as rice, maize, cowpea and soybean by 34 %, 52.7%, 164% and 23% respectively between 2017 and 2020 under the PFJs programme (MOFA, 2021).

The high illiteracy rate among farmers especially female farmers is a serious challenge which makes it difficult for them to access information on pesticide use and source of credit for inputs and other related expenses. The other identified challenge during the study was the fact that many of the input suppliers especially their representatives (sales agents) are not skilled or competent enough to offer informed advice on the proper and safe use of agrochemicals and could mislead the farmers. Trainings organized by the Plant Protection and Regulatory Services Directorate (PPRSD) of MOFA and the Environmental Protection Agency (EPA) are always attended by the suppliers themselves and not the agents. It also showed that apart from the extension services (16%) as the main source of information, respondents get information from other sources such as other farmers, retired agriculture workers, chemical dealers, and family members (Table 5).

Knowledge and information flow from various disseminators to the farmers within the area's agriculture production value chain environment is shown in Figure 8.

Discussion

Socio- economic survey

It is established that 60 % of the respondents fall between the ages of 20 and 40 years and therefore necessary for serious attention to be given to them in terms of education on good agricultural practices to ensure the observance of these practice. This age range is very important for any nation as it is the most economically active group. There is also a high level of gender inequality in terms of tomato production as only eighteen percent (18%) of the respondents are female, an indication that income from this sector is skewed to the male farmers. The revelation relates to a report by the United Kingdom Department for International Development (2010) that total agricultural outputs in Africa could increase by up to 20% if women's access to agricultural inputs was equal to men's.

The educational levels of the farmers are very important as literate farmers are able to read and understand any technology including the use of pesticides. It also showed quite a good picture as majority of the respondents had at least basic education (Table 1). Despite the fact that majority of the respondents have some form of basic education, misuse of pesticides is still a problem among them. A study by Oyekale and Idjesa (2009) showed that the level of education has effect on skills acquisition and technology adoption among farmers. However, as the saying goes that "experience is the best teacher", the results showed a positive situation as 66% of the respondents have six or more years of experience in the industry. Therefore, even if illiterate farmers are into tomato production for up to six years and above, they would be able to learn and gain experience to produce safe and healthy crops. Unfortunately, this is not so as many of the farmers are not using pesticides appropriately. It could be that they do not appreciate the risks and dangers associated with the misuse of pesticides or they have been abusing the use all these years.

Access to knowledge and information about the crop and how to produce it and handle problems associated with the crop is critical in sustainable and environmentally friendly agriculture. It is therefore sad that even though there are extension workers stationed in the operational areas of the study communities the results showed that 64% of the respondents have no access to extension (Table 2). It is further known that those who have access (36%) do not

have regular contact with the extension agent as only 10% and 18% of the respondents have weekly and fortnightly contact respectively with the extension agent. This confirms Tanzubil and Boatbil (2014), Williamson (2003) and Bull (1982) that farmers in developing countries including Ghana do not have adequate knowledge of pests control including pesticides use. The majority (70%) of the farmers relied on other farmers for information which is quite disturbing as wrong practices could be spread to the whole of the farming community. As shown in Figure 2, the majority (70%) of the respondents acknowledge that they need more education on tomato production including chemical pests and disease control. From this revelation, it means that other forms of pests management is not available to the farmers to learn and adopt. It should also be noted that the extension worker: farmer ratio in the country of 1: 1500 and sometimes 1:3000 in some districts (MOFA, 2003), might be an important factor for the inadequate extension delivery for tomato farmers in the district. It has also been established that apart from the low extension worker: farmer ratio, logistical support is woefully inadequate as the majority of the extension workers do not have means of transport to cover the area assigned to them. This may be the reason why the farmer contacts with the AEA are very low (Table 6). The involvement of NGOs in extension delivery as far as vegetable production is concerned has been poor in the study area. It showed that 85% of the respondents have not interacted with any NGO on vegetable production and pests control including the use of pesticides.

Despite the impressive number of farmers with six or more years of experience, respondents did not know the effects of chemicals on the environment (Table 7), as they referred to pollution of water bodies in the mining areas of the country saying they did not know of water pollution caused by agrochemicals. The high incidence of reported poisoning during pesticide use confirms a finding at Akumadan in the Offinso North District and some parts of northern Ghana where pesticide poisoning was common among vegetable farmers (NPAS, 2012; Ntow et al., 2006; Ntow, 2001). The knapsack sprayer is the most popular spraying machine among the farmers probably due to the sizes of their fields and its affordability. Ntow et al. (2006) and Memuna et al. (2015) had similar findings at Akumadan and Ashiaman respectively with the use the knapsack sprayer except where farmers with fields over five acres used motorized sprayers such as the mist blower. According to them these farmers sprayed weekly or every 10 days, whether the level of the pest reached economic injury level or not. This was also established by Haleegoah et al. (2004) where calendar spraying led to the excessive spray of pesticides on vegetables in the Kumasi Metropolis. It is believed that biochemical analysis for pesticides residue in the tomato and other vegetables in the district would be positive.

All respondents depend solely on chemical pesticides for control of pests and diseases especially insect pests. This finding is in keeping with earlier reports that showed that in some parts of Accra, Asante Akim North and Sekyere Kumawu districts in Ashanti region where pesticides use was found to be the most popular pests management strategy as 65%-96% of farmers applied chemicals and in some case more than four times before harvest (Manu et al., 2021; Osei et al., 2013). The report concluded that cabbage like most vegetable farmers abuse the use of synthetic products such as pesticides and chemical fertilizers with its environment implications. The attitude of farmers in using pesticides indiscriminately through harvest has been confirmed by several workers (Amoako et al., 2012; Afari-Sefa et al., 2015; Donkor et al., 2016). They applied pesticides within the last 3 to 7 days before harvest and sometimes do not respect any waiting period as found in this study.

Hand-picking of insect pests such as grasshoppers and caterpillars as a control method is common on backyard gardens and not on large acreage as it is cumbersome and not practicable. Some of the respondents dispose empty containers on the field with the belief that other farmers especially the new entrants would know the chemical they used and termed the practice as information sharing mechanism.

Farmers' knowledge and practice of alternative pests control

There was a clear indication that the majority of respondents did not know of integrated pests management (IPM) and its practices and mostly use pesticides in their quest to fight pests and diseases. This is in keeping with a studies by Tanzubil and Boatbil (2014), Wandaat and Kugbe (2015) in the Upper east region and Ahafo regions of Ghana respectively where farmers did not have adequate knowledge in IPM practices and relied solely on pesticides to control pests and diseases. This may be considered an indictment on the part of the District Agriculture Directorate for failing to at least establish demonstrations on IPM practices in these communities. Precautions before, during and after pesticides use are essential for sound chemical pests control for the applicants and the environment at large. The majority of the respondents do not use the appropriate protective equipment during spraying. This may be due to a high level of ignorance and/or the cost of the protective gear leading to the high incidence of poisoning and intoxication among the farmers. Clarke et al. (1997) encountered a similar situation in the Accra plains where the vegetable farmers were lacking personal protective equipment (PPE) which was causing poisoning among the farmers. Observation of safety periods for re-entry or harvest is crucial in chemical pests control especially when it is insecticides and fungicides. It is alleged that vegetable farmers do not observe actual safety periods and the results of this study have confirmed this ill practice. As indicated above, Clarke et al. (1997) reported in the Accra plains where re-entry to the field few hours to three days after spraying recorded 88.9% with one week recording 11.0 % of the respondents. This malpractice may be due to ignorance coupled with the desire for quick money.

Knowledge generation and information dissemination to farmers

The CSIR-CRI and the CSIR-SARI are institutes of the CSIR-Ghana that are responsible for knowledge generation with respect to crops including vegetables for the forest and savannah agro-ecological areas of the country respectively. This is then passed on to the farmers through the extension services department of the Local Government Service and the Ministry of Food and Agriculture (MOFA). The Agriculture Extension Agents (AEAs) are mostly college-

level graduates holding certificate and/or diploma in general agriculture certificate. There are now many first degree holders in the districts as extension workers. The Ghana Institution of Horticulturists (GhIH), a professional body interested in the promotion of horticultural crops including vegetables and fruits sometimes organizes seminars, workshops, etc. for some vegetable farmers throughout the country.

Conclusion

Chemical pests control is the main control method known and practised by most commercial tomato farmers in the area. It is therefore consistent with the earlier works which indicated that a chemical pesticide is the main control method among vegetable farmers in Ghana and other developing countries (James et al., 2010). Farmers believe chemical pests' control has come at the right time to liberate them from the drudgery and the 'old way' of farming. It is a common practice among tomato farmers to apply chemical pesticides as many times as possible to control pests, some times without regard to the cost and effects on the crop and the environment.

It has been established that vegetable farmers in the area have inadequate knowledge on alternative pests and diseases control methods. The traditional methods of pests control such as the use of ash and hand picking is not feasible in commercial vegetable production. Others such as biological control are not known by the farmers. The use of botanicals like neem extract to control pests is not known and practiced by majority of the respondents. Integrated pests management (IPM) is not practiced mainly due to the lack of knowledge and expertise. The benefits of alternative pests and diseases control are enormous as vegetables are safe for consumers and the farmer is less exposed to poisoning while maintaining a sound environment. There is a huge gap between farmers' quest for knowledge on pests control methods (alternative and pesticides) and their access to knowledge and information. It is interesting to note that extension officers are available in most of the communities but impact is not much realized since their contact with the farmers (especially tomato farmers) is not impressive. This could be due to the fact that they (extension officers) have a lot of farmers to contact, and are also constrained logistically. Many of these farmers therefore, depend very much on their fellow farmers for knowledge and information, which sometimes could be misleading.

The reduction of pesticides use would not be possible in the foreseeable future considering the level of agrochemical influx into the country and the level of education given to the farmers. Unless there is a special intervention by the authorities in launching an alternative pest control programme including biological pesticides, IPM, etc. in the vegetable producing areas of the country. The tomatoes fruit worm *(Helicoverpa armigera*) is said to be one of the most notorious insect pests in the area. The Pesticide Action Network-UK (PAN-UK) once acknowledged the resistance of this pest to many insecticides (PAN-UK, 2002) and has been reported in recent times by Manu et al. (2021) in some parts of Ashanti region Vegetable production including tomato is a very lucrative business and well established in many parts of the country including the study area. The production of vegetables and tomato will be on the increase to meet the growing demands due to the increasing population and people's change in staple foods. This therefore, implies the control of pests and diseases would continue to be a major issue confronting these farmers as they would want to increase production and incomes.

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