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Research article

The need for alternative pest management methods to mitigate risks among cocoa farmers in the Volta region, Ghana

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ABSTRACT

The objective of this study is to assess the adoption of alternative pest management methods to reduce risks among cocoa farmers in the Volta region. Cultural control methods found to be the most practiced alternative pest management, especially in the Ho West district where majority of the farmers were more knowledgeable of alternative pest control methods. There was significant relationship between agrochemical shop services (χ^2 = 13,028, $p < 0.000$), farming years of experience ($\chi^2 = 16.424$, $p < 0.002$), knowledge in degree of pest infestation ($\chi^2 = 8.498$, $p < 0.000$), education ($\chi^2 = 10.557$, $p < 0.014$), farmers' community ($\chi^2 = 39.275$, $p < 0.000$) and farmers' knowledge on alternative pest control methods. Farmers who relied on agrochemical shop services for pest control methods were 87% less likely to be knowledgeable on alternative pest control methods while those who considered degree of pest infestation in pest management were (OR = 1.150, $p < 0.008$) more likely to be knowledgeable on alternative pest control methods. For the socio-cultural factors, Leklebi Kame (OR = 9.53-e 08, $p < 0.000$), Bla (OR = 0.280, $p < 0.027$) and Gbledi Chebi (OR = 0.287, $p < 0.053$) were less likely to be knowledgeable on alternative method of pest control compared to Kpedze. Fellow farmers and extension agents were the major sources of information on alternative pest control methods in the study area. Economic, technical, unavailability of labour, and farm implements were factors hampering adoption of alternative pest control methods in the study area. The most pesticide toxicological symptom reported was skin irritation and was recorded among majority of the farmers in Hohoe and Afadjato South districts where low knowledge and patronage of alternative pests control methods were identified. Awareness creation and capacity building programs should be organized through fellow farmers and extension agents on the need to reduce the use of chemical pesticide in pest management.

1. Introduction

The cocoa sector generates about 70–100% of the annual income for about 800,000 smallholder farmers in Ghana. The sector also provides, food, employment, tax revenue and foreign exchange earnings for Ghana (Danso-Abbeam et al., 2014; Denkyirah et al., 2016). Even though cocoa is economically important, its production in Ghana is threatened by insect pests and diseases. The major economic pests and disease of cocoa production in Ghana include mirids and black pod respectively (Antwi-Agyakwa, 2013; Paintsil, 2017). This situation has led to the decline in cocoa production and subsequently the adverse impact on the Ghanaian economy (Denkyirah et al., 2016). According to Owusu-Manu (2001), the use of synthetic insecticides has been the main method recommended by the Cocoa Research Institute of Ghana (CRIG) for insect pests management (Antwi-Agyakwa et al., 2015). The use of pesticide in the Ghanaian agriculture, though beneficial in reducing crop loss both before and after harvest (Clarke et al., 1997), has been associated with threats to human health, detrimental consequences for the environment and future chances for farming (Millstone and Lang, 2013). Inadequate knowledge and negative attitude (Gesesew et al., 2016; Ibitayo, 2006; Nalwanga and Ssempebwa, 2011) refusal to use or unsuitable PPE and improper storage at residence are causes of injury and death among farmers. Delon (2019) reported that farmers suffer from health problems such as headache, diarrhea, vomiting, nausea, blurred vision, dizziness and abdominal cramps due to poor safety practices during pesticide handling.

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In view of the prospective effects of pesticides on humans and the environment, alternative pest control methods such as cultural, mechanical, botanical pesticides and crop rotation have been practiced by farmers to reduce the use of chemical pesticides leading to improvement in food safety, human health and environmental conservation (Kinuthia et al., 2019). Even though, government and non-governmental organizations have made efforts to promote alternative pest control methods, its adoption is still very low (Kinuthia et al., 2019). At certain instances, farmers are still not aware of the integrated pest management (IPM) as a pest control method in their pest control practices (Ashraf et al., 2012). This may be attributed to inefficient transfer of information about alternative pest control methods among farmers (Allahyari et al., 2017).

Allahyari et al. (2017) reported in a study to evaluate farmers' knowledge of IPM in olive production that farming experience, increased community involvement and education promote farmers' technical knowledge in IPM. Uwagboe et al. (2012) reported that there exist a significant association between education, membership association, sex and IPM utility. Kinuthia et al. (2019) also reported that farmers' age, group membership and education increased their intensity of uptake of alternative pest control options. Although work has been done on IPM, little attention has been given to the use of alternative pest management (APM) practices as risk mitigation strategies by cocoa farmers. This study therefore, aimed at assessing the adoption of alternative pest management practices among cocoa farmers in the Volta region of Ghana.

2. Materials and method

2.1. Study area

The study was carried out in three districts (Hohoe, Afadjato South, Ho West) out of six cocoa growing districts in the Volta region of Ghana as in Figure 1. The region derived its name from the River Volta which separates it from the rest of the country and serves as the largest source of Ghana's fresh water fish. Volta region is located between latitudes 5° 45′ N and 8° 45′ N. It shares boundary with the Republic of Togo to the East, Greater Accra region to the West, to the North with Oti region and has the Gulf of Guinea to the South. It has a total land area of 20,570 square kilometers, representing 8.7 percent of the total land area of Ghana. The regional population was 2,118,252 according to the 2010 national census. The region has a tropical climate, characterized by rainy and dry seasons and moderate temperatures, 21–32 °C (70–90°F) for most of the year. April to July and September to November are the main rainy seasons in the region (GSS, 2013). The major agricultural products include cocoa and staples such as maize, rice, sorghum, cassava, yam, cocoyam and plantain. The region used to be one of the country's major cocoa growing areas. However, this has declined over the years as a result of poor agronomic practices. The region is characterized by beautiful landscape, clean environment, numerous eco-tourism sites and the rich cultural heritage epitomized by Kente weaving, making it one of the most important tourists areas of attraction in the country. Some of the tourist sites in the region include Amedzofe Mountain, Tagbo Falls near Hohoe, Tafi Atome Monkey Sanctuary and Xavi Bird Watching Sanctuary. Others include the Wli Waterfalls in the Hohoe District and the Kpetoe Kente Village (GSS, 2013).

2.2. Sampling procedure and sample selection

A multi-stage sampling procedure was employed for the study. Volta region was purposively selected as one of the cocoa growing regions in Ghana. Three districts, Ho West, Afadjato and the Hohoe were randomly selected as one of the cocoa growing districts in the Volta region as in Figure 1. Three cocoa growing communities from each of the districts were randomly selected. In order to avoid bias and improve the validity and reliability of the study, a simple random sampling technique by Cohen et al. (2000) was used to select twenty-five (25) farm households from each of the three communities selected earlier (Kosivi, 2020).

A questionnaire was used to solicit information from the farmers. The questionnaire was structured mostly with closed-ended questions and a few open-ended ones and administered using one-on-one interviews. The closed-ended questions were used to obtain the exact information being

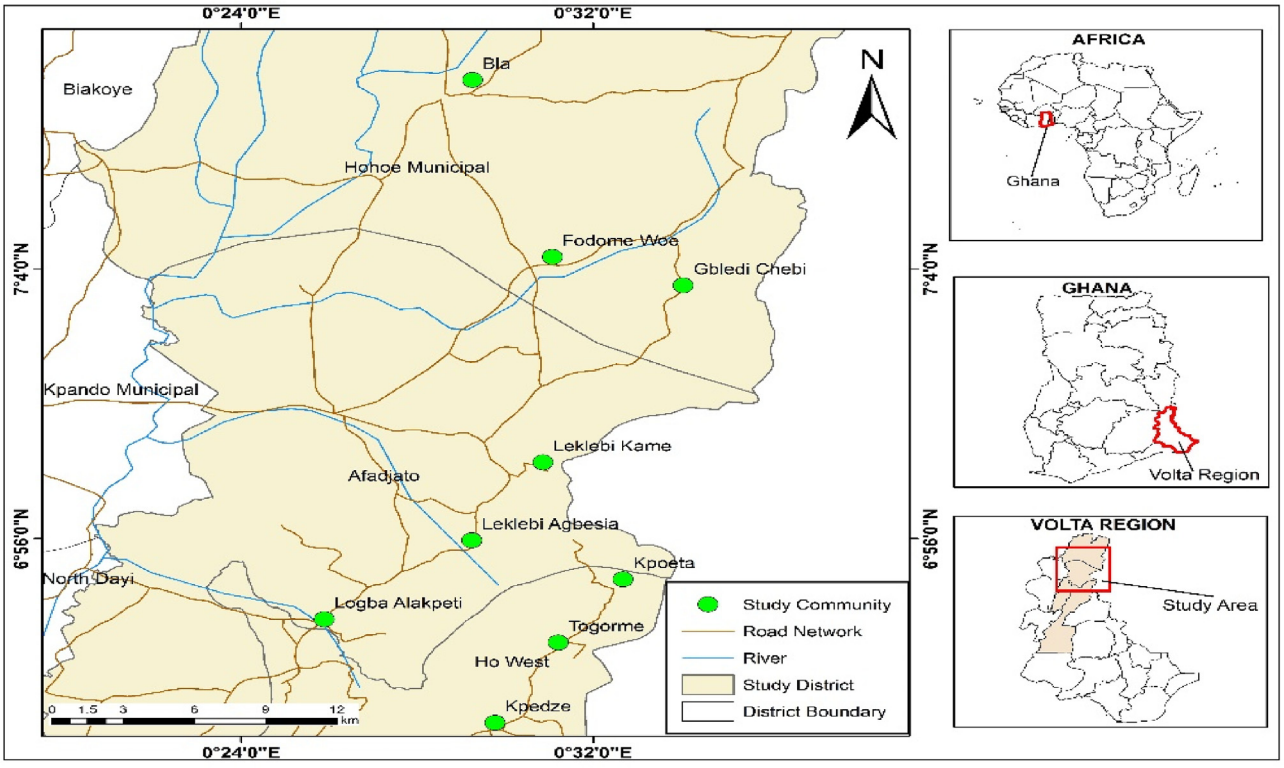

Figure 1. Map of study area and selected communities in Hohoe, Afadjato South and Ho West Districts.

sought to be collected for quantitative analysis, whilst the open-ended ones gave the respondents more room to clarify certain responses provided. The questionnaire was administered in English, but few of the farmers with difficulty with the English language, the researcher translated to the local language (Ewe) of the area. Selection of farmers for interview was not biased towards any gender, religious or political affiliation. Participants were neither coerced nor financially induced to take part in the study. The study design was approved by the University of Cape Coast Institutional Review Board (IRB). A priori permission was sought from the village chief farmers and other appropriate opinion leaders in each selected community and were briefed on the purpose of the study before any farmer was interviewed. This ensured that farmers received the interviewers through the proper chain of command in each community to enhance the accuracy of information given (Kosivi, 2020).

2.3. Variables

2.3.1. Response variable

The dependent variable considered was knowledge in alternative pest control method. For this variable, respondents were asked if they had any knowledge in alternative pest control method. The dichotomous response was coded as 0 (for no), 1 (for yes).

2.3.2. Key predictor variables

The key independent variables were selected based on literature, parsimony, practical significance, model fit, theoretical relevance and previous experience. The key explanatory variables were agrochemical shop services, knowledge on degree of pest infestation and farming years of experience, education and community of the farmers (Allahyari et al., 2017; Kinuthia et al., 2019; Uwagboe et al., 2012).

2.3.3. Compositional and contextual factors

Compositional factor refers to socio-cultural characteristics of individuals. Socio-cultural factors include marital status, income, education, occupation, and religion among others (Collins et al., 2017; Pol and Thomas, 2012). The compositional factors considered in this study included education (no formal education, primary, secondary or tertiary). Contextual factors are location-specific opportunities in a region or a place (Ross and Mirowsky, 2008). The contextual factor selected includes the following community of residence i.e. Kpedze, Togorme, Kpoeta, Leklebi kame, Logba Alakpeti, Leklebi Agbesia, Bla, Gbledi Chebi and Fodome Woe.

2.4. Data and statistical analyses

Data were analyzed using the IBM SPSS version 20 and Stata version 13 software. Data analyses included univariate and multivariate statistics. The inferential statistics was used to evaluate the associations between agrochemical shop services, farming years of experience, knowledge in degree of pest infestation, education, farmers' community and farmers' knowledge on alternative pest control methods by using the Pearson Chi-square. The Pearson Chi-square was used to estimate the association between categorical variables. The Chi-square test of independence is a nonparametric statistical test that is used to determine if two or more group of samples are independent or not (Armah et al., 2018; Yeager, 2020).

The relationships between agrochemical shop services, farming years of experience, knowledge in degree of pest infestation, education, farmers' community and farmers' knowledge on alternative pest control methods were determined using generalized linear models (GLMs). The above factors were estimated using a complementary log-log model and reported as exponential coefficients or odds ratios (OR). An OR of 1 means that predictor does not affect odds of influencing farmers' having knowledge on alternative methods of pest control; OR $>$ 1 means that predictor is associated with higher odds of influencing; farmers' having knowledge on alternative methods of pest control; and OR $<$ 1 means that predictor is associated with lower odds influencing farmers' knowledge on alternative methods of pest control. In this study, a complementary log-log regression model was fitted to binary outcomes data at the multivariate level. The complementary log-log transformation is expressed as:

$$\log\{-\log(1-p)\} = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k = Z \quad (1)$$

where, β_o = the constant of the equation, $\beta_{1,2,3}$ = the coefficient of the explanatory variables 1, 2, 3 to be estimated; $X_1 \ldots X_k$ are sets of explanatory variables; p is the predicted probabilities; and log{−log (1 − p)} is the link function.

$$-\log(1-p) = e^{(\beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k)} \quad (2)$$

As the probability increases, the transformation approaches infinity more slowly than either the probit or logit. In using Eqs. (1) and (2), the relationship between the response variable and the explanatory or predictor variable was modelled.

3. Results

3.1. Socio-demographic characteristics of respondents

The results of the distribution of cocoa farmers from the three districts (Ho West, Afadjato South and Hohoe) who used pesticides by socio-demographic attributes (gender, age, education and years of experience), their knowledge and awareness of alternative pest control method, alternative pest control methods practiced and their components, source of information about alternative pest control method and the challenges faced by farmers while practicing alternative pest control methods. Socio-cultural factors influencing farmers' knowledge of alternative pest management, contextual differences in significant predictors of farmers' knowledge of alternative pest control method and the output of the multivariate logit, complementary log-log and the pesticide toxicological symptoms experienced by farmers were as well presented in this section.

The results presented in Table 1 show that majority of the respondents were males with Afadjato South recording the highest (96%) and the lowest (92%) in Ho West. With regards to age, majority (59% and

Table 1. Socio-demographic characteristics of respondents.

Variable	Ho West	Afadjato South	Hohoe
	Frequency (%)	Frequency (%)	Frequency (%)
Gender			
Male	69 (92)	72 (96)	71 (95)
female	6 (8)	3 (4)	4 (3)
Age			
Young Adult	12 (16)	7 (9)	3 (4)
Middle age adult	31 (41)	38 (51)	44 (59)
Old age adult	32 (43)	30 (40)	28 (37)
Education			
No formal education	2 (3)	5 (7)	3 (3)
Primary education	43 (57)	47 (63)	47 (63)
Secondary education	26 (35)	20 (27)	20 (27)
Tertiary education	4 (5)	3 (3)	5 (7)
Years of experience			
1–3 years	2 (3)	1 (1)	9 (12)
4–6 years	14 (19)	30 (40)	18 (24)
7–10 years	26 (35)	12 (16)	31 (41)
10 and above years	33 (44)	32 (43)	17 (23)

Values in parentheses indicate percentages (%).
Majority of the farmers from Ho West (44%) and Afadjato South (43%) had more than 10 years' experience while those from Hohoe (41%) had between 7-10years of pesticide use experience.

51%) respondents from Hohoe and Afadjato South respectively were in the middle age adult group while those from Ho West (43%) were in the old age adult group (Table 1). The results in Table 1 also revealed that educational levels of the farmers were very low as majority (63%) of respondents from Afadjato South and Hohoe each had primary education while 57% of those from Ho West had primary education.

3.2. Farmers' knowledge, awareness of alternative pest control methods and those practiced

Pearson Chi-square and Cramer's V statistic were used to determine whether the observed differences in farmers' knowledge and awareness of alternative pest control method, alternative pest control methods practiced as well as the farmers' location (districts) were independent. The results are shown in the contingency Tables 2 and 3. The results show that there were statistically significant differences in farmers' location and knowledge of alternative pest control ($\chi^2 = 20.303$, df = (2), $p < 0.000$), awareness of alternative pest control method and their location by cultural method ($\chi^2 = 6.756$, df = (2), $p < 0.034$), mechanical method ($\chi^2 = 10.734$, df = (2), $p < 0.005$), botanical method ($\chi^2 = 15.672$, df = (2), $p < 0.000$), resistant variety ($\chi^2 = 52.080$, df = (2), $p < 0.000$) and superficial ($\chi^2 = 15.672$, df = (2), $p < 0.000$) (Table 2). Table 3 shows that there were statistically significant differences in farmers' location and the alternative pest control methods practiced by cultural method ($\chi^2 = 6.475$, df = (2), $p < 0.039$), mechanical method ($\chi^2 = 11.759$, df = (2), $p < 0.003$) and botanical method ($\chi^2 = 14.075$, df = (2), $p < 0.0001$). However, resistant variety and superficial methods were not significant. This means that the null hypothesis independence of these variables was rejected. It also means that the result for the sample would likewise be true for the larger population of the cocoa farmers from which they were drawn. It also suggests that farmers' locations influence their knowledge and awareness of alternative pest control methods and the type of alternative pest control methods practiced. The associations between farmers' locations (districts) and their knowledge and awareness of alternative pest control methods and the type of alternative pest control methods practiced were strong based on (Crame'r's V > 0.3) and the proportion of χ^2 statistics.

3.3. Components of the alternative pest control methods practiced by the farmers

When the farmers who responded that they used alternative methods aside from the chemical pesticides to control pests and diseases were asked to name the components of the methods they practiced, shade management, early weed control, destruction of infested parts of cocoa and timely harvest were mentioned under the cultural method, hand-picking of insect pests and their eggs for crushing, trapping of rodents, using objects to kill red ants and mealy bugs on cocoa trees were under mechanical method. For the biological method, the use of neem (*Azadirachta indica),* garlic (*Allium sativum),* ginger (*Zingiber officinale)* and wood ash were mentioned while the planting of disease and pest resistant species was mentioned under resistant variety. Interestingly, the use and belief of supernatural powers by the burning of certain dry leaves to drive insect pests away (accompanied with traditional prayers) was also mentioned as an alternative pest control component (Table 4).

3.4. Relationship between socio-cultural characteristics of respondents and knowledge of alternative pest control

The results in Table 4 revealed that significant relationships exist between agrochemical shop services ($\chi^2 = 13.028$, $p < 0.000$), farming years of experience ($\chi^2 = 16.424$, $p < 0.002$), knowledge in degree of pest infestation ($\chi^2 = 8.498$, $p < 0.000$), education ($\chi^2 = 10.557$, $p < 0.014$), farmers' community ($\chi^2 = 39.275$, $p < 0.000$) and farmers' knowledge of alternative pest control methods. This implies that agrochemical shop services, farming years of experience, knowledge in

Table 2. Farmers' knowledge and awareness of alternative pest control methods.

Variable	Ho West	Afadjato South	Hohoe	Measure of Association
	Frequency (%)	Frequency (%)	Frequency (%)	
Knowledge on alternative method of pest control				
No	43 (57)	60 (80)	66 (88)	Pearson χ^2 (df = 2) = 20.303
				p = **0.000** Crame'r's V = 0.300
Yes	32 (43)	15 (20)	9 (12)	
Cultural				
No	12 (86)	2 (14)	0 (0)	Pearson χ^2 (df = 2) = 6.756
				p = **0.034** Crame'r's V = 0.347
Yes	20 (48)	13 (31)	9 (21)	
Mechanical				
No	17 (63)	10 (37)	0 (0)	Pearson χ^2 (df = 2) = 10.734
				p = **0.005** Crame'r's V = 0.438
Yes	15 (52)	15 (17)	9 (31)	
Botanical				
No	18 (75)	0 (0)	6 (25)	Pearson χ^2 (df = 2) = 15.672
				p = **0.000** Crame'r's V = 0.529
Yes	14 (44)	15 (47)	3 (9)	
Resistant variety				
No	1 (4)	15 (60)	9 (36)	Pearson χ^2 (df = 2) = 52.080
				p = **0.000** Crame'r's V = 0.964
Yes	31 (100)	0 (0)	0 (0)	
Supernatural				
No	32 (58)	14 (26)	9 (14)	Pearson χ^2 (df = 2) = 52.080
				p = **0.000** Crame'r's V = 0.964
Yes	0 (0)	1 (100)	0 (0)	

Values in parentheses indicate percentages (%): p = probability (significant at < 0.05) and df = degrees of freedom.

Table 3. Distribution of alternative pest control methods practiced by farmers.

Variable	Ho West	Afadjato South	Hohoe	Measure of Association
	Frequency (%)	Frequency (%)	Frequency (%)	
Cultural				
No	7 (39)	5 (28)	6 (33)	Pearson χ^2 (df = 2) = 6.475 p = **0.039** Crame'r's V = 0.340
Yes	25 (66)	10 (26)	3 (8)	
Mechanical				
No	8 (32)	11 (44)	6 (24)	Pearson χ^2 (df = 2) = 11.759 p = **0.003** Crame'r's V = 0.458
Yes	24 (77)	4 (13)	3 (10)	
Botanical				
No	16 (73)	0 (0)	6 (27)	Pearson χ^2 (df = 2) = 14.075 p = **0.001** Crame'r's V = 0.501
Yes	16 (47)	15 (44)	3 (9)	
Resistant variety				
No	31 (56)	15 (27)	9 (16)	Pearson χ^2 (df = 2) = 0.764 p= 0.683 Crame'r's V = 0.117
Yes	1 ((100)	0 (0)	0 (0)	
Supernatural				
No	32 (58)	14 (26)	9 (16)	Pearson χ^2 (df = 2) = 2.783 p= 0.249 Crame'r's V = 0.223
Yes	0 (0)	1 (100)	0 (0)	

degree of pest infestation, education and farmers' community are determinants of farmers' knowledge on alternative pest control meth-ods.

3.5. Likelihood of farmers to be knowledgeable in alternative methods of pest control

Table 5 shows the odd ratios (OR), robust standard error (SE), probability values (p-values) and confidence intervals (CI) associated with the key factors (agrochemical shop services, farmers' years of experience and degree of pest infestation) that predict farmers' knowledge in alternative methods of pest control as well as socio-cultural (education) and contextual factors (farmers' community). Model 1 shows that farmers who relied on agrochemical shop services were 62% less likely to be knowledgeable in alternative methods of pest control compared to their counterparts who did not consider agrochemical services when considering pest control. However, farmers who considered the degree of pest infestation in pest management (OR = 1.621, p < 0.004) were more likely to be knowledgeable in alternative pest control approach compared to their counterparts who do not consider degree of pest infestation when deciding on which methods to use to control pest (Table 6).

The results in model 2, in which socio-cultural factors were controlled, show that farmers who with access to agrochemical services (OR = 0.383, p < 0.036) were less likely to be knowledgeable in alternative methods of pest control compared to their counterparts who did not rely on agrochemical services when dealing with pest control. Again, farmers who considered degree of pest infestation in pest management (OR = 1.619, p < 0.004) were more likely to be knowledgeable in alternative methods of pest control compared to their counterparts who do not consider degree of pest infestation in pest management (Table 6).

In model 3, contextual factor which influences farmers' knowledge of other methods of pest control apart from the use of pesticides was considered. The community of the respondents was controlled for in the model. The socio-cultural factors mediated the relationship between the main predictors and the community of the respondents. With regards to the communities, Leklebi Kame (OR = 9.53−e 08, p < 0.000), Bla (OR =

Table 4. Distribution of some components of alternative pest control practiced by farmers.

Variable	Ho West	Afadjato South	Hohoe	Alternative Pest Control Component
	Frequency (%)	Frequency (%)	Frequency (%)	
Cultural				
No	7 (39)	5 (28)	6 (33)	Shade management, early weed control, destruction of infested parts of cocoa and timely harvest
Yes	25 (66)	10 (26)	3 (8)	
Mechanical				
No	19 (53)	11 (31)	6 (17)	Handpicking of insect pests, eggs, caterpillars, for crushing, trapping of rodents, using of objects
to kill red ants and mealy buds on cocoa tress				
Yes	13 (65)	4 (20)	3 (14)	
Botanical				
No	16 (73)	0 (0)	6 (27)	Use of extracts from ginger, neem, wood, ash and garlic
Yes	16 (47)	15 (44)	3 (9)	
Resistant species				
No	31 (56)	15 (27)	9 (16)	Planting of disease and pest resistant species
Yes	1 (100)	0 (0)	0 (0)	
Supernatural				
No	32 (58)	14 (26)	9 (16)	Burning of certain dry leaves to drive insect pests away (accompanied with traditional prayers)
Yes	0 (0)	1 (100)	0 (0)	

Values in parentheses indicate percentages (%).

Table 5. Chi-square (χ^2) showing significant relationship between socio-cultural characteristics of respondents and knowledge of alternative pest control.

Variable	Chi-Square	p- Value
Agrochemical shop services	13.028	0.000
Farming years of experience	16.424	0.002
Knowledge in degree of pest infestation	8.498	0.000
Education	10.577	0.014
Farmers' community	39.275	0.000

*Significant at 0.05 level of probability (p).

0.280, $p < 0.027$) and Gbledi Chebi (OR = 0.287, $p < 0.053$) were less likely to be knowledgeable in other methods of pest control compared to Kpedze. However, the result of agrochemical services and degree of pest infestation remained the same in all the three models (Table 6).

3.6. Sources of information on alternative methods of pest control practiced by the farmers

The chi-square and Cramer's V statistics were employed to determine the magnitude effect size of the relationship between farmers' location and source of information about alternative pest control methods and challenges faced during the practicing of alternative pest control methods. The results show that there were statistically significant differences between farmers' locations (districts) and the sources of information on the alternative pest control methods practiced by agrochemical shops (($\chi^2 = 9.435$, df = (2), $p < 0.009$), fellow farmers (($\chi^2 = 6.808$, df = (2), $p < 0.033$), farmer' own experience (($\chi^2 = 7.692$, df = (2), $p < 0.021$) and extension services ($\chi^2 = 6.120$, df = (2), $p < 0.047$) (Table 7) and challenges faced during the practicing of alternative pest control methods by economic ($\chi^2 = 6.418$, df = (2), $p < 0.040$), unavailability of neem plant ($\chi^2 = 10.922$, df = (2), $p < 0.004$), lack of labour ($\chi^2 = 6.962$, df = (2), $p < 0.031$), and lack of tools/implements ($\chi^2 = 6.113$, df = (2), $p < 0.047$) except technical challenges (Table 8). This suggests that farmers' location influences the source of information on the type of alternative pest control method practiced and the challenges they face in practicing the methods. The Cramer's V statistic showed strong association between farmers' location and source of alternative pest control method, same association was observed for farmers' location and challenges faced in executing alternative pest control methods.

3.7. Some challenges faced by famers in practicing of alternative pest control methods

During the field interview, farmers mentioned constraints that prevented the practice of alternative pest control methods as, unavailability of labour, economic, unavailability of neem plant, technical and lack of farm implements/tools (Table 8). Majority of farmers in Ho West had challenges regarding technical knowledge (68%), economic (48%), unavailability of neem plant (69%), lack of labour (42%) and unavailability of tool/implements (64%) while only a few farmers faced these challenges in Hohoe district, technical knowledge (26%), economic (12%), unavailability of neem plant (14%), lack of labour (19%) and unavailability of tool/implements (11%).

3.8. Distribution of farmers' pesticide toxicological symptoms

The pesticide toxicological symptoms reported by the farmers are shown in Table 9. The results indicated various symptoms of toxicological effects due to pesticide application as reported by the farmers. The highest (34%) headache was recorded in Ho West while the lowest (32%) were in Hohoe district. The highest reported cases of burning eye sensation (36%), general body weakness (35%), fever (37%), watering eye (36%), skin rashes (39%) and skin irritation (35%) were reported in Ho West, Hohoe, Ho West, Hohoe, Ho West and Hohoe while the lowest (29%, 32%, 30%, 31%, 29% and 31%) were recorded in Afadjato South, Afadjato South, Afadjato South, Afadjato South, Afadjato South and Ho West districts respectively. The results also show that the highest cases of dizziness (37%), chest pain (36%), were reported in Afadjato South and

Table 6. Complementary log-log predicting factors influencing farmers' knowledge in alternative methods of pest control.

Variable	Key determinants (Model 1)					Socio- cultural factors (Model 2)					Contextual factors (Model 3)				
	OR	SE	P	Conf.	Int.	OR	SE	P	Conf.	Int.	OR	SE	P	Conf.	Int.
Agrochemical shop services (Ref: No)															
Yes	0.379	0.185	**0.047**	0.146	0.987	0.383	0.175	**0.036**	0.156	0.938	0.405	0.130	**0.005**	0.216	0.758
Farmer's experience (Ref: 1–2 years)															
4–6 years	0.537	0.265	0.208	0.204	1.413	0.551	0.286	0.251	0.199	1.526	0.653	0.307	0.365	0.260	1.641
7–10 years	1.147	0.484	0.745	0.501	2.623	1.071	0.482	0.880	0.443	2.589	1.012	0.465	0.980	0.411	2.493
More than 10 years	0.885	0.372	0.771	0.389	2.015	0.841	0.384	0.704	0.344	2.056	0.732	0.330	0.488	0.302	1.771
Degree of pest infestation (Ref: No)															
Yes	1.621	0.272	**0.004**	1.167	2.252	1.619	0.267	**0.004**	1.171	2.237	1.510	0.234	**0.008**	1.114	2.046
Education (Ref: no formal education)															
Primary education						0.611	0.209	0.149	0.313	1.194	0.640	0.209	0.172	0.338	1.214
Secondary Education						1.018	0.340	0.956	0.529	1.960	1.183	0.401	0.619	0.609	2.298
Tertiary education						0.981	0.369	0.960	0.470	2.049	1.065	0.428	0.876	0.484	2.342
Community (Ref: Kpedze)															
Togorme											1.145	0.242	0.522	0.757	1.732
Kpoeta											1.275	0.285	0.278	0.822	1.975
Leklebi kame											9.53e−08	2.93e−08	**0.000**	5.22 e−08	1.74 e−07
Logba Alakpeti											1.423	0.341	0.142	0.889	2.276
Leklebi Agbesia											0.560	0.248	0.191	0.235	1.334
Bla											0.280	0.161	**0.027**	0.091	0.864
Gbledi Chebi											0.287	0.185	**0.053**	0.081	1.014
Fodome Woe											0.817	0.310	0.594	0.388	1.718

OR= odd ratios; SE = standard error; p = probability (significant at 0.05 level); Conf. Int. = Confidence Intervals.

Table 7. Sources of information on alternative pest control methods used by farmers.

Variable	Ho West	Afadjato South	Hohoe	Measure of Association
	Frequency (%)	Frequency (%)	Frequency (%)	
Agrochemical shops				
No	23 (64)	5 (14)	8 (22)	Pearson χ^2 (df = 2) = 9.435
				p = **0.009** Crame'r's V = 0.410
Yes	9 (45)	10 (50)	1 (5)	
Fellow farmers				
No	8 (36)	8 (36)	6 (28)	Pearson χ^2 (df = 2) = 6.808
				p = **0.033** Crame'r's V = 0.349
Yes	24 (71)	7 (21)	3 (8)	
Own experience				
No	18 (75)	2 (8)	4 (17)	Pearson χ^2 (df = 2) = 7.692
				p = **0.021** Crame'r's V = 0.371
Yes	14 (44)	13 (41)	5 (15)	
Extension officers				
No	13 (65)	7 (35)	0 (0)	Pearson χ^2 (df = 2) = 6.120
				p = **0.047** Crame'r's V = 0.321
Yes	19 ((53)	8 (22)	9 (25)	

Values in parentheses indicate percentages (%); p = probability (significant at < 0.05); df = degrees of freedom.

Hohoe districts respectively while the lowest (31% and 31%) were in Ho West and Afadjato South respectively. With regards to highest cases of forgetfulness, vomiting and diarrhea, 47%, 56% and 46% were all reported in Hohoe districts (Table 9).

4. Discussion

4.1. Socio-demographic characteristics of respondents

The data showed that males dominate cocoa farming in the study area. This could be due to the difficulty women go through in acquiring land for cash crop production in Ghana, coupled with the laborious nature of the chemical application activity. This obervation is in line with Uwagboe et al. (2012) who reported that women suffer to get land for tree crop production in Nigeria. The male to female ratio in this study supports earlier report by Denkyirah et al. (2016), Okoffo et al. (2016) and Paintsil (2017) who reported that cocoa farming in Ghana is dominated by males.

Technology adoption is affected by age and also serves as the basic latent characteristics in adoption decisions (Uwagboe et al., 2012). The mean age of the farmers was 51 years, with the minimum being 20 years and the maximum 84 years. Thus, the finding in this study is in line with Okoffo et al. (2016). This generally signifies that cocoa farmers in the three districts are old and ageing. This may affect cocoa production in the future since one's health normally declines with age unless the trend changes.

Farmers' educational level affect the decisions they take in terms of adoption of new technology and engagement in activities that will not have adverse effects on the environment and human health. However, majority of the farmers in the three districts had primary education, and since the farmers have some form of formal education, they may be able to read and understand pesticide labels to some extent except critical task such as calibration of sprayers and adoption of alternative pest control options. According to Adejumo et al. (2014), educated farmers seem to be easier adaptors to new technologies and are more likely to be earlier adopters.

Most of the farmers in the study area have adequate farming experience with the majority of them coming from Ho West and Afadjato South districts. This finding agrees with Adesuyi et al. (2018), Denkyirah et al. (2016), Okoffo et al. (2016) who reported that majority of the farmers in

Table 8. Some challenges faced by famers in practicing alternative pest control.

Variable	Ho West Frequency (%)	Afadjato South Frequency (%)	Hohoe Frequency (%)	Measure of Association
Technical				Pearson χ^2 (df =2) = 4.771
No	4 (27)	7 (47)	4 (26)	p = 0.092
Yes	28 (68)	8 (20)	5 (12)	Crame'r's V = 0.292
Economic				Pearson χ^2 (df = 2) = 6.418
No	13 (81)	3 (19)	0 (0)	p = **0.040**
Yes	19 (48)	12 (30)	2 (22)	Crame'r's V = 0.339
Unavailability of neem plants				Pearson χ^2 (df = 2) = 10.92
No	3 (22)	8 (57)	3 (21)	p = **0.004**
Yes	29 (69)	7 (17)	6 (14)	Crame'r's V = 0.442
Lack of labour				Pearson χ^2 (df = 2) = 6.962
No	19 (76)	3 (12)	3 (12)	p = **0.031**
Yes	13 (42)	12 (39)	6 (19)	Crame'r's V = 0.352
Lack of tools/implements				Pearson χ^2 (df = 2) = 6.113
No	3 (27)	4 (36)	4 (36)	p = **0.047**
Yes	29 (64)	11 (24)	5 (11)	Crame'r's V = 0.330

Values in parentheses indicate percentages (%); p = probability (significant at < 0.05); df= degrees of freedom.

Table 9. Distribution of farmers' pesticide toxicological symptoms.

Toxicological Symptoms	Ho West	Afadjato South	Hohoe
	Frequency (%)	Frequency (%)	Frequency (%)
Headache			
Not experienced	30 (32)	30 (32)	33 (36)
Experienced within the week	45 (34)	45 (34)	42 (32)
Burning Sensation in eye			
Not experienced	33 (40)	24 (29)	25 (31)
Experienced within the week	42 (29)	51 (36)	50 (35)
General body Weakness			
Not experienced	25 (33)	27 (36)	23 (31)
Experienced within the week	50 (33)	45 (32)	52 (35)
Fever			
Not experienced	23 (27)	33 (38)	30 (35)
Experienced within the week	52 (37)	42 (30)	45 (32)
Skin rashes			
Not experienced	41 (38)	29 (27)	37 (35)
Experienced within the week	34 (29)	46 (39)	38 (32)
Watering eyes			
Not experienced	38 (33)	41 (36)	36 (31)
Experienced within the week	37 (34)	34 (31)	39 (36)
Skin irritation			
Not experienced	27 (39)	22 (32)	20 (29)
Experienced within the week	48 (31)	53 (34)	55 (35)
Forgetfulness			
Not experienced	57 (42)	46 (34)	34 (25)
Experienced within the week	18 (21)	29 (33)	41 (47)
Vomiting			
Not experienced	66 (36)	66 (36)	52 (28)
Experienced within the week	9 (22)	9 (22)	23 (56)
Diarrhea			
Not experienced	59 (35)	61 (36)	49 (29)
Experienced within the week	16 (29)	14 (25)	26 (46)
Dizziness			
Not experienced	46 (36)	40 (31)	45 (34)
Experienced within the week	29 (31)	35 (31)	30 (32)
Chest pain			
Not experienced	36 (34)	38 (36)	33 (31)
Experienced within the week	39 (33)	37 (31)	42 (36)

Values in parentheses indicate percentages (%).

Nigeria and Ghana had adequate farming experience respectively. This high experience in cocoa production is likely to influence their adoption of cocoa technologies such as application of pesticides for pest and diseases control.

4.1.1. Farmers' knowledge and awareness of alternative pest control methods

Mirids and black pod were identified as the major economic pest and disease of cocoa respectively in the study area. Surprisingly, majority of the farmers had a little knowledge of alternative pest control method apart from the chemical pesticides. Farmers from Hohoe district recorded the least (12%) knowledge in alternative pest control methods while the highest (43%) in Ho West district. This is in consonance with Alalade et al. (2017) who reported that majority, more than 70% of the farmers knew of the chemical pesticide control method. This suggests that chemical pesticide is the major means of pest and disease control method in the study area, most especially in the Hohoe district. This is worrisome since its adverse effects on human health and the environment is great. Most of the farmers claimed they had found the chemical pesticide to be the most labor-saving, effective and efficient means of pest control and this finding is in agreement with Damalas and Eleftherohorinos (2011). In a similar study, Ngowi et al. (2007) reported that over reliance of farmers on chemical pesticides is an indication that they are not aware of other pest management methods which are effective, inexpensive yet environmentally friendly.

The farmers who claimed to have knowledge of other methods of pest control mentioned cultural, mechanical, botanical pesticides, resistance varieties and supernatural as alternative pest control methods they were aware of. It is obvious from the result that the most known alternative method of pest control in the study area is the cultural method and the least is the resistant variety and supernatural. Farmers in the Ho West district showed the highest awareness of the cultural method and the least was seen in Hohoe district. However, the resistant variety and the supernatural methods are known only in Ho West and Afadjato districts respectively. This finding is in variance with Alalade et al. (2017) who stated that majority of the farmers at Kwara State in Nigeria were aware of the cultural method. The dominance of the awareness of the cultural control method among the other methods may be attributed to its inclusion in the cocoa disease and pest control (CODAPEC) training program for farmers in the country (Naminse et al., 2011). Additionally, cultural methods which include early harvesting of cocoa, timely weed control, removal of infested parts of crops among others are easy to practice and do not need a lot of technical assistance. Farmers and extension officers should be given more awareness and technical assistance in other methods of pest control.

4.2. Alternative pest control methods practiced by the farmers and their components

When the farmers who reported that they used alternative methods aside from the chemical pesticides to control pests and diseases were asked to name the methods they practiced, cultural, mechanical, botanical pesticide, resistant variety and superficial were mentioned. The most practiced among them was the cultural method. In Kwara State in Nigeria, all farmers practiced cultural method (Naminse et al., 2011). The cultural method was mostly practiced by farmers in the Ho West while least practiced in Hohoe district. The fact that the cultural method is the most practiced alternative method by the farmers may be attributable to its being economical and easy to practice with a little or without technical support. According to Satti (2012), cultural method is the commonly known simplest, cheapest and the safest method to combating pests and diseases of agricultural crops. The farmers mentioned early harvesting, shade management, early weed control, fertilizer application and sanitation and destruction of infested residues as some of the cultural activities they carried out to control pests and diseases on their farms.

The mechanical method which includes handpicking of insect pests and their eggs for crushing, trapping of rodents, using objects to kill red ants and mealy bugs on the cocoa trees was practiced by majority of farmers from the Ho West district and least practiced in the Hohoe district. The fact that majority of the farmers in the Ho West district engage in the mechanical method may be attributed to their high knowledge in alternative pest control methods and the effectiveness of the method. According to the farmers even though the method was effective, it was very laborious, time consuming and very difficult to practice for large scale production farming (Obiri and Driver 2017). They also added that the method worked effectively for slow moving pests and those that are conspicuous since some camouflage themselves with the color of the vegetation, an observation which lends similarity to Litsinger (1994), and Maxwell (1985) therefore, making them inaccessible. Farmers should, therefore, be trained and equipped with the necessary farm tools to ease the difficulty associated with the mechanical method.

Majority of farmers from Ho West district were found using the botanical pesticide to control pests and diseases while the least were found in the Hohoe district. Most farmers in the Ho West district use the botanical pesticides because they consider these pesticides more effective and less toxic. Botanical pesticides are considered very important in pest management due to their high efficacy, biodegradability, varied mode of

action, low toxicity as well as readily availability of source materials (Lengai et al., 2020; Neeraj et al., 2017). Besides, they have short half-lives as reported in Dutta (2015) and Lengai et al. (2020) and are gaining popularity due to their use for crops that are grown for human consumption (Lengai et al., 2020; Misra, 2014). However, due to challenges in formulation and commercialization which are attributed to lack of chemical data and positive controls, botanical pesticides have not been fully adopted (Lengai et al., 2020).

A farmer from Ho West district reported the planting of diseases and pests' resistant variety of cocoa. The use of host resistant species is not only the most effective and practical means of pest and diseases control but also helps to avoid and reduce chemical pesticides usage. However, identifying the pests that are most damaging and finding suitable and resistant varieties are important steps in pest control, since agricultural plant varieties are rarely resistant to all pests and diseases in a specific area (Caldwell et al., 2013; Obiri and Driver, 2017). Therefore, Cocoa Research Institute of Ghana (CRIG) should be resourced to bring out pest and disease resistant varieties of cocoa that suit the conditions of the study area for cultivation.

Interestingly, a farmer from the Afadjato South district revealed the use of supernatural powers to drive insect pests away from his farm. This method involved the burning of certain dry leaves such as neem, accompanied with traditional prayers. According to the farmer, the presence of some pests on the farm was an indication that the gods have been offended. Moore and Lenglet cited in Pennacchio et al. (2010) reported that the most widely used method to repel insect pests in the tropics is smoke. Again, in Nigeria about 12% of the farmers currently use smoke as a method of controlling pests, which has tremendously reduced fungal aflatoxin attack (Pennacchio et al., 2010). Therefore, the spiritual reasons attached to this method (ethnobotany) must be investigated scientifically to enable other farmers who are not traditionalist to embrace this environmentally friendly pest control method. Farmers should be made to believe that these plants contain natural pest repellents which drive-off the insect pests. In the light of above, farmers should be engaged when developing new agricultural technologies since some of them are knowledgeable in natural methods of controlling pests and diseases.

4.3. Relationship between socio-cultural characteristics of respondents and knowledge on alternative pest control

We found that there was an association between farmers' knowledge of alternative pest control methods and the agrochemical retailers. Agrochemical shop dealers play a very critical role in the dissemination of agricultural information to farmers, and farmers rely on them as the primary information and knowledge source on pesticide (Jallow et al., 2017). According to Alam and Wolff (2016), agrochemical retailers down play health effects of pesticides and the environment when dealing with farmers for profit-making. Hence, farmers who depend on agrochemical sellers for advice on pest management will hardly adopt alternative method of pest control. Thus, agrochemical shop service influences alternative method of pest control negatively.

Farmers' years of experience was also found to significantly influence their knowledge in alternative method of pest control. Farmers who are experienced in chemical method of pest control would hardly adopt other methods, hence would be less knowledgeable in alternative method of pest control. More experienced famers are less likely to go into new technologies compared to less experienced ones. Service and Service (1987) reported that farmers who adopt IPM are less experience than non-adopters. On the other hand an experience with negative health effects with pesticides in the past is one of the most important predictors for the application of more safety measures (Khan and Damalas, 2015) and the adoption of alternative pest control methods.

Degree of pest infestation, which considers the number of insect pests per tree in determining what method of pest control to adopt, was found to have an association with farmers' knowledge of alternative pest control. Degree of pest infestation is a key tool in IPM that helps to reduce the use of chemical pesticides. Therefore, farmers who consider degree of pest infestation in pest management process are more likely to be more knowledgeable in alternative pest control methods than their counterparts.

We further discovered that there was an association between farmers' knowledge of alternative pest control methods and their levels of education. This may be attributed to the fact that education of farmers positively influences their ability to uptake information with ease. Educated farmers are able to access information with ease, process it and apply it as required (Kinuthia et al., 2019). The finding of this study is in accordance with (Khan and Damalas, 2015).

Farmers belonging to the same social group and so share and exchange ideas easily within the community. Thus, the farmers learn from one another, the benefits and usage of new technologies (Mwangi and Kariuki, 2015). The members of a social group also exert pressure on each other in the adoption of new technologies. Therefore, any technology that is accepted by the majority is easily transferred and adopted by the community members as a whole.

4.4. Likelihood of farmers to be knowledgeable in alternative methods of pest control

The results of the study revealed that farmers who depended on agrochemical services were less likely to be knowledgeable in alternative methods of pest control compared to their counterparts. The presence of agrochemical shops positively influenced farmers to use pesticides as means of pest control (Anang and Amikuzuno, 2015). Due to low farmer-extension ratio, many farmers rely on agrochemical dealers for basic chemical information on selection of pesticides and other relevant information on pesticides use. Unfortunately, most of the employees of the agrochemical operators lack technical knowledge and operates with the mindset of profit making. Thus, the actions of agrochemical dealers may generate conflict of interest in prescribing the best pest control methods to the famers and the sale of their products (Rijal et al., 2018). Extension officers should intensify education on the adoption and the benefits of IPM to reduce the use of the chemical pesticides.

Degree of pest infestation which explains the pest population per plant is very important when considering options for pest control in IPM (Felsot and Racke, 2006). We observed that farmers who considered degree of pest infestation to decide on pest control method were more likely to be knowledgeable of alternative methods of pest and diseases control methods. This is because they consider the cost effectiveness when deciding on pest control methods. For those who do not consider degree of pest infestation, chemical pesticides are applied anytime there is pest infestations. Those knowledgeable in IPM will use pesticides based on the observations made, regarding pest population (Mariyono, 2007). Thus, they consider the number of pests per cocoa tree to decide on what action to take. According to Denkyirah et al. (2016), majority of cocoa farmers indicated that the presence of pests and diseases on cocoa trees informed them as to when to apply pesticide. The target of the farmers who do not consider degree of pest infestation is to eradicate the pests rather than managing them. On seeing the pests, they try to eradicate them instantly without considering the severity of pests and diseases infestation and which crop management practice to adopt (Mariyono et al., 2018).

We also discovered that Farmers from Bla, Gbledi Chebi and Leklebi Kame were less likely to be knowledgeable on alternative methods of pest control compared to those from Kpedze. This may be due to the fact that the most common pest control method used in these communities is the chemical pesticide method. According to Taher (1996) and Van der Werf et al. (2007), the exchange of information in smaller communal communities is usually easy, fast, and frequent. This is because members have close relations. Moreover, the socio –economic factors establishing the communities are the same, hence may affect the farmers level of technology adoption. The interactions among the members create the avenue

to exchange useful ideas as well as exerting pressure on members' behaviors. Therefore, cooperate groups in the farmers' communities should be engaged in the transfer of knowledge on alternative pest control methods to the farmers.

4.5. Sources of information on alternative methods of pest control practiced by the farmers

The major source of accessing information on alternative methods of pest control was extension services followed by fellow farmers. This result is in variance with the findings of Alalade et al. (2017) who reported that the major means of accessing information on pest control method was television followed by extension and friends/family and the others were radio, agrochemical shop and newspapers. It is obvious that fellow farmers, extension service and experienced farmers can be important agents by which information can be extended to the farmers. It is therefore, suggested that these channels be used by governmental agencies and other stakeholders in the cocoa industry to reach out to farmers on new agricultural practices and technologies.

4.6. Some challenges faced by farmers in the practicing of alternative pest control methods

Unavailability of labour, economic, unavailability of neem plant, technical and lack of farm implements/tools were some of the challenges faced in adopting the alternative pest control methods in the region. This is not different from the findings of Aneani (2012). Lack of implements/tools was found to be the most challenging factor in the adoption of alternative pest control method most especially in the Ho West district. This may be due to the large numbers of rodents in that area Some also added that botanical method has been found to be very effective. However, the challenge they faced was the unavailability of the neem in their communities and the difficulty in the extraction process, a finding in consonance with Dormon et al. (2007). Ghana COCOBOD should tackle these bottlenecks to motivate farmers to adopt IPM technology in Cocoa growing communities. In spite of the challenges mentioned above, some farmers are still motivated to engage in some form of alternative methods of pests and diseases control. This is attributed to the risks they faced with over-dependence of synthetic pesticides application.

4.7. Pest/disease control methods and toxicological symptoms

The fact that majority of the farmers used solely chemical pesticides for pests and disease control implies that chemical pesticides are heavily used to control pests and disease in the area. This findings also corroborate previous studies by Antwi-Agyakwa (2013) and Osei-Boadu (2014) who discovered that the most common pest control method employed by the farmers in the study areas was the use of synthetic chemicals. Abang et al. (2014), who conducted a study among vegetable farmers in Indonesia, on pesticide use and its determinant, concluded that about 92% of the farmers relied on pesticides to control pests and diseases. Denkyirah et al. (2016) reported similar trend of pesticide use in Ghana. The overuse of chemical pesticides can be attributed to the fact that extension officers though have good knowledge in pests and diseases, lack alternative pest control methods hence, recommend only chemical pesticides use to the farmers.

It was discovered that various degrees of pesticide toxicological symptoms were reported by the farmers. Skin irritation was the commonest symptom reported and the highest recorded in Hohoe district. Out of these symptoms, 58% and 33% were recorded in Hohoe and Afadjato districts respectively. This may be due to the fact that majority of the farmers in the two districts have less knowledge of alternative pest control methods and so depend solely on the chemical pesticides for pests and diseases control. This is in agreement with Ngowi et al. (2007) who reported that about 68% of farmers experienced pesticide related health symptoms such as skin problems, headache and dizziness. However, the reporting of less cases of pesticides related health symptoms in Ho West district may be due to the fact that majority of the farmers have knowledge and also practice alternative pest control methods. Majority of farmers reporting pesticide toxicological symptoms may be as a result of poor knowledge regarding pesticide use and unsafe practices such as the use of PPE's. Inadequate knowledge and negative attitude (Gesesew et al., 2016; Ibitayo, 2006; Nalwanga and Ssempebwa, 2011) and poor safety practices such as non-use of PPE's and improper storage of pesticides at residence are causes of morbidity and mortality of pesticide exposure among farmers (Gesesew et al., 2016; Mekonnen and Agonafir, 2002; Sivayoganathan et al., 1995). Some of the famers in the study area who reported health symptoms of pesticide toxicity considered that to be normal with the work they do. The worrying aspect of the finding is the fact that some of the farmers even associated some of the health symptoms to the difficult nature of the spraying exercise hence they rarely report these symptoms to health centers for treatment. These findings are also in consonance with Kishi et al. (1995) and Ngowi et al. (2007) who reported that farmers thought that pesticide poisoning symptoms were normal and that with time, they got used to them. The result is also similar to a study carried out in Ivory Coast, Indonesia and Tanzania Ajayi (2000), Kishi et al. (1995) and Ngowi et al. (2007), where pesticide applicators tend to accept a certain level of illness as an expected and normal part of the work of farming, and therefore, do not report the symptoms in official health centers for formal medical assistance. These findings may be attributed to poor PPE use during mixing and application of pesticides identified in the study area coupled with disregard for pesticide use safety protocols. Education and training in alternative pest control methods, safe minimal use of pesticides should be intensified in the region to avert these challenges.

5. Conclusion

The findings of this study revealed that farmers from Hohoe and Afadjato South districts had low knowledge and patronage of alternative pests and diseases control methods. This means that majority of the farmers in these districts depend heavily on chemical or synthetic pesticides for pests and diseases control. However, a greater number of their counterparts in the Ho West district had high knowledge and patronage of alternative pests and diseases control methods. Major sources of information on alternative pest control method in the three districts came from extension services and fellow farmers. The findings also revealed that agrochemical shop services, farming years of experience of farmers, knowledge in degree of pest infestation, farmers' education and farmers' location (community) influenced the choice of farmers' knowledge of alternative pest control methods. Also, more than half of the farmers reported at least five toxicological symptoms due to pesticides application.

Finally, the commonest reported pesticide related heath symptoms by the farmers during or after pesticide application in the three districts was skin irritation recorded in Hohoe, Afadjato South districts. and in Ho West district. This is not surprising since majority of the farmers in these districts use lots of pesticides to control pests and diseases. Poor pesticide handling and application practices may have resulted in the prevalence of pesticide related health symptoms in Afadjato South and Hohoe districts. Thus supporting our work that the use of alternative pests and diseases control method should be encouraged to reduce farmers' exposure to pesticide risks.

Farmers should also be given economic, technical and financial supports to be able to adopt alternative pest control methods with ease. This is because, reduction in chemical pesticide application burden is key in pollution mitigation and the overall impacts on human health and the environment.

Declarations

Author contribution statement

Michael Miyittah, PhD; Samuel Kofi Tulashie, PhD: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Richard K. Kosivi, Mphil; Maxwell N. Addi, Mphil; Josephine Y. Tawiah, Mphil: Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

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Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no competing interest.

Additional information

No additional information is available for this paper.

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