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Pesticide registration, distribution and use practices in Ghana

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Abstract Ghana has implemented regulation on the registration, distribution and usage of pesticides in order to evaluate their environmental and human health effects. However, environmental monitoring and certified laboratories for pesticide analysis are lacking. Pesticide misuse, misapplication, contamination of the environment and human exposure still continue, and little is known to what extent pesticide registration, distribution and use is properly implemented in Ghana. This study aimed at investigating how the pesticide policy operates in Ghana, how state (policy; national/local) and non-state (importers, dealers' and farmers) stakeholders function, what their challenges are, and to which extend the policy objectives are achieved. A conceptual framework based on the contextual interaction theory (CIT) was developed, and a review of Ghana's pesticide policy implementation with two empirical field studies on state policy and non-state policy actors was conducted, supplemented with secondary data, and a number of interviews conducted with stakeholders and informants were used. Results indicate that pesticides are registered in compliance with the law. Non-state actors scored low with respect to their mandate which likely results in environmental and human health risks. Significant association existed between

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educational level attained and knowledge ($\chi^2 = 3.614$; $P \leq 0.05$). Work experience or duration of farming also significantly influenced the knowledge of respondents ($P < 0.001$), as well as attitude ($\chi^2 = 15.328$; $P < 0.05$). Work experience/duration of farming also significantly influenced attitude at 95% confidence level ($P < 0.001$), and duration of farming was significantly associated with farm management practices at 5% level of significance ($P \leq 0.05$), while state actors are not motivated and resourced. It is recommended to perform preliminary risk assessment to the aquatic environment, to derive threshold levels which are protective of communities, to screen farmers for pesticide exposure and poisoning, to develop well-targeted training programmes for pesticide retailers and farmers on pesticide use, personal protective device use, as well as pesticide management and law. Additionally, pesticide policy implementers have to be motivated and resourced to carry out their mandate, being to execute the pesticide legislation.

Keywords Pesticides · Registration · Policy · Implementation · Actors · Ghana

1 Introduction

Pesticides use in agriculture in Ghana has resulted in reduced crop loss (Clarke et al. 1997). There has been a continuous increase in the importation and use of pesticides (Ministry of Food and Agriculture 2011). This include both the number of chemicals and quantities registered as well as recorded by the competent authorities and regulators such as the Food and Drugs Authority (FDA), Environmental Protection Agency (EPA) of Ghana, Ghana Standards Authority (GSA) and the Ministry of Food and Agriculture (MOFA). This increase is prevalent due to the expansion of cultivation areas for food and cash crops in a bid to meet the increasing demand for food (Ministry of Food and Agriculture 2003). The increase can also be attributed to the liberalization of the economy and the government's aim of attaining a middle income economy as enshrined in the country's Vision 2020 agenda. Further, the regulation and the registration of pesticides opened a new economic boom with the resultant increase in the registration of pesticide products for use in Ghana. The use of pesticides, however, has not been without deleterious effects on people, such as farmers, traders and consumers, which are involved in the food supply chain. Poor knowledge of farmers on the types of pesticides, their use and associated risks, ineffective governmental enforcement of pesticides' regulations and strong incentives among pesticide traders and users to make profits have been reported leading to an increased use of cheap, mislabelled and adulterated pesticides in Ghana (Northern Presbyterian Agricultural Services and Partners, 2012; GNA 2012). Instances of over use and misuse on crops have been reported with the accompanying negative effects on productivity, environment and human health (Gerken et al. 2001; Amoako et al. 2012; Dinham 2003). Williamson et al. (2008) described chlorpyrifos, endosulfan and lambda cyhalothrin being associated with instances of ill health among Ghanaian farmers. Ntow (2001) detected endosulfan and lindane in water and sediment of streams in areas of intensive tomato farming, while other organochlorine pesticide residues were also found in sediment. Similar results were recorded by Ntow (2005) for the Volta Lake in Ghana.

With these problems, there has been a shift to the use of relatively "safer" pesticide alternatives which gave birth to the implementation of the pesticide registration process of Ghana in 2003. The pesticide law at the time was the Pesticide Control and Management Act, Act 528 of 1996. The law has been consolidated to become Part II of the main

Ghana Environmental Protection Agency (EPA) Act, Act 490 of 1994. This law includes the whole pesticide life cycle, and also the registration and procurement of pesticides, their import, distribution and retail to farmers, their monitoring for quality control and waste management.

Since the implementation of the pesticide registration process, a number of interventions such as training courses on pesticide storage and handling and their proper use have been organized for importers, distributors, retailers and farmers by the state and a number of non-state organisations (NSOs). However, little is known regarding how and to what extent the registration, distribution and use of pesticides is properly implemented in Ghana. It is also not clear whether these actions by the registration authorities have yielded the necessary improvements in pesticide management and their use. This is so because the operationalization of the pesticide law lacks extensive and reliable information that could be available to experts, scholars, researchers and practitioners in this field of enquiry. The main objective of this paper is to examine how pesticides are registered, distributed and used and to assess how different state (policy implementers) and non-state (distributors and the farmers) pesticide actors can improve the governance of pesticides in order to increase their environmental sustainability as well as workers' health in Ghana.

1.1 Pesticide law in Ghana: registration, distribution and use (regulatory framework)

Ghana has a pesticide legislation, part II of the Environmental Protection Agency (EPA) Act (Act 490), which governs the whole pesticide life cycle. The legislation helps to assure that pesticides are used in a safe way in the country. The Ghana EPA is responsible for the registration of pesticides as well as their management. They do this to ensure that the pesticides are properly labelled, distributed, stored, transported, used and applied by following the accepted procedures and processes. The Ghana EPA further monitors pesticide use and, if needed, react against illegal use, and issues pesticides importation and use licences. The registration of pesticides is headed by a Pesticides Registrar who works with a Pesticides Technical Committee which includes a wide background of expertise and institutions (section 53 of the Act) and which advises the Ghana EPA Board whether pesticides should be registered or not.

The Plant Protection and Regulatory Services Directorate (PPRSD), of the Ministry of Agriculture, through the Pesticide and Fertilizer Regulatory Division Act 803 (2010) compliment the Ghana EPA. They supervise and train pesticide inspectors, register and inspect pesticide dealers and provide information materials and training on pesticides, among others, for retailers and farmers.

To tackle illegal trade in pesticides, the Customs Division of the Ghana Revenue Authority regulates all imports into Ghana including chemicals under Act 791 (2009). Under the auspices of the Ghana EPA, the customs division examines documents and certificates issued by the Ghana EPA. The aim is to validate the claim of the bearer regarding a particular importation. The law (Act 791) gives customs officers the jurisdiction to search for certain persons, premises and baggage and seize prohibited items, including pesticides.

Ghana, in the exercise of its duty on pesticides, recognizes international legal agreements relating to pesticides. These include the International Code of Conduct on the Distribution and Use of Pesticides (i.e. the FAO Code of Conduct). Ghana is also a signatory to the Rotterdam Convention on Prior Informed Consent (ratified in 2003), which facilitates the sharing of information between countries and prevents that banned or severely

restricted pesticides are exported and imported. Furthermore, the Stockholm Convention on Persistent Organic Pollutants aims to safeguard human health and the environment from effects of persistent organic pollutants (POPs) and is subscribed to by the country (ratified in 2003).

1.2 Pesticides registration procedure in Ghana

Ghana's pesticide registration is a stepwise process (Fig. 1), which assesses available and submitted data and results in a final decision to grant or deny registration. The process aims to identify potential risks that may arise from the sale and use of pesticides under Ghana's conditions and culture (EPA-Ghana 2012).

The process includes: (1) the application for registration, (2) data on chemical and physical properties, toxicology, efficacy, residues and fate in the environment of the active ingredient and formulated product, (3) several specific requirements like an agency agreement between the agent and the manufacturer, a batch certificate of analysis, (4) locally generated efficacy data form, (5) samples of the pesticide, (6) a manufacturing licence in the country of origin and (7) the package label in English (EPA-Ghana 2012).

Application for the registration of a pesticide involves the submission of a product dossier with the necessary annexures to the registrar (EPA-Ghana 2012). The complete application is scientifically scrutinized by technical sub-committees on environmental and human toxicology, bio-efficacy, labelling and advertisements. An evaluation report and recommendations on the application are then submitted to the Pesticide Technical Committee (PTC).

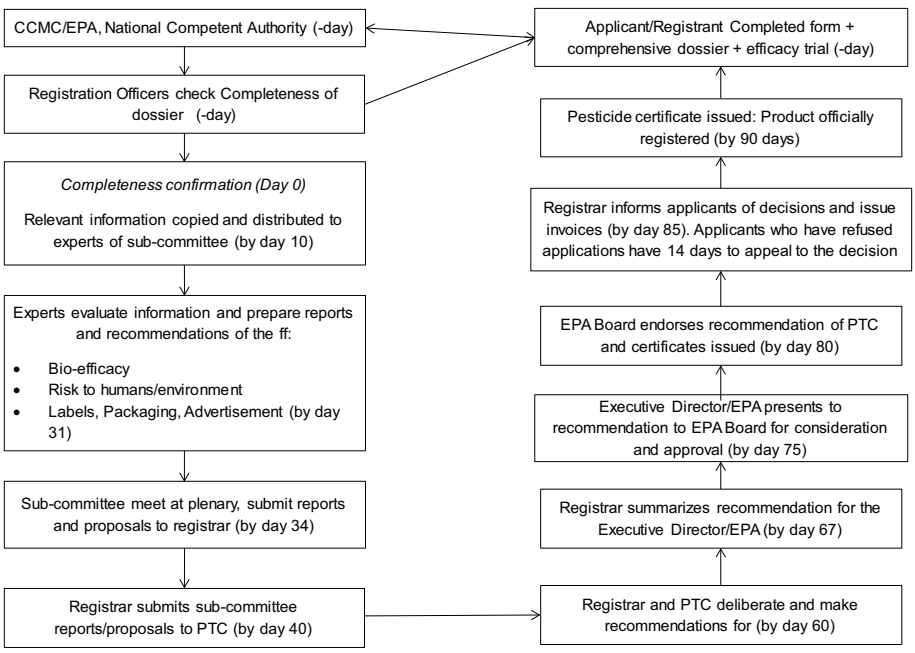

Fig. 1 Pesticide registration dossier and application scheme

The PTC evaluates the report and proposes a registration decision for deliberation by the Ghana EPA Board. The decisions could be full registration valid for 3 years and can be renewed. A provisional clearance permit lasts between 6 months to 1 year, in which case the applicant is supposed to submit additional information for further consideration. An experimental permit can also be issued for the purposes of research. Decision on banned products (banned for use locally or internationally) or suspension of the registration (inability of the Board to reach a decision) can also be reached (EPA-Ghana, 2012). These permits can also be renewed upon expiry. Registered pesticides are subsequently gazetted into public communication channels, as the media.

The Ghana EPA is responsible for verifying the registration and the import of pesticides by issuing a clearance permit, after the importer submitted an application which includes the data as requested by the Ghana EPA. Under the Ghana EPA Act, "a person shall not import, export, manufacture, distribute, advertise or sell a pesticide except in accordance with a licence issued under this Act" (EPA-Ghana 2012). For the storage of pesticide products, a pesticide licence is required. Pesticide licences are issued based on the presence of a satisfactory location of the storage facility upon inspection by the Ghana EPA.

Pesticide clearance permits are required for an importer to clear consignments from the port based on availability of pesticide licence and if the imported pesticide product is registered.

1.3 Theoretical framework for analysing policy implementation

A conceptual framework based on the contextual interaction theory (CIT) was developed for the study from the review of the policy implementation literature (Fimyar 2014; Sabatier 1991; Van Horn and Van Meter 1977). The theory as described by Bressers (2007) indicates that implementing a policy is a social process where the output and outcome are defined by the interactions of its actors. The framework evaluates how a policy operates in practice, how state (registration authorities) and non-state (pesticide dealers and farmers) actors are functioning and whether the policy objectives are achieved. Outputs are the tangible results of a measure or the noticeable effects shortly after or even during implementation (Bressers 2007). The Ghana pesticide registration offers a number of outputs that are supposed to be implemented by state actors and the outputs that are supposed to yield certain desired outcomes by the non-state actors. The CIT thus offers an opportunity to evaluate whether the desired outcome has been achieved or not. The CIT brings to the fore a couple of actor characteristics including information, motivation and resources. These were selected for the purpose of this study to better understand their impact on the likelihood to implement a policy. The governance approach focuses on the interaction taking place between governing actors with information, motivation and resources (Mengistie et al. 2014). The interaction shapes actors and actors shape interaction patterns. The three variables information, motivation and resources may mutually influence each other as well (Bressers 2007; Harder 2008; Karwai 2005; Logan 2010; Locke and Letham 2004).

Many research efforts have shown that the characteristics of a policy network may be a useful base for elucidating the functioning of a policy instrument and its design (e.g. de Bruijn and Hufen 1998). The concept of policy networks generally contains the assumption that there are both links and actors (Carlsson 2006). The implementation process of the policy gets its particular shape through such networks. This conceptual framework (evaluation model) is used to link the registration and policy on the one hand and use practices at farm level on the other hand.

This policy evaluation framework is realized by the different governance approaches focusing on the interaction between governing actors; so the output depends on actor performance (Figure S1). These actors are brought into perspective in the three key ingredients of this study:

1. Policy input and objective. What is the pesticides policy and what are its objectives which are used by the administration to produce outputs? Such resources would include personnel, finance, pesticides registration documents (international chemical conventions, regulation, dossier for pesticides registration, among others) and what the policy says about state and non-state actors of pesticides regarding environment and human health safety and sustainability.
2. Policy implementation process. This refers to the roles of authorities, companies, non-governmental organizations and individuals. Information on how, why and under what circumstances these actors are involved in the course of policy implementation is important. There is the need to identify who are important actors and stakeholders and what they are doing related to safe pesticides registration, distribution and use. There is the need to focus on agricultural and environmental offices from national to local level. This should involve the importers in the country, pesticides inspectors, extension workers, wholesalers, retailers (since they are important source of pesticides for farmers) and farmers associations.
3. Policy output. This entails the issues and challenges listed by the target groups (farmers) who are faced with, e.g. selection and use of certain products. This is the group where the noticeable effects occurring shortly after or even during implementation can be observed.

This study aims to evaluate (1) how the pesticides policy functions, how state (national and local policy) and non-state (importers, dealers' and farmers) actors are functioning, (2) the extent to which the policy is implemented and enforced including the challenges encountered and (3) whether the enacted policy achieves its objectives.

2 Study area and methodology

This study was based on Ghana's pesticides law and two empirical field studies on state policy and non-state policy actors were conducted. Data for this study were supplemented with secondary data and a number of interviews conducted with stakeholders and informants.

2.1 Study area and actors

Two empirical surveys were conducted. For the first survey, purposeful sampling was used to select the locations to interview non-state actors (distributors, retailers and farmers). This was done to select those distributors and retailers who had interactions with the regulatory bodies. Farmers were chosen if they applied pesticides themselves, interacted with the pesticides dealers and extension staff. Interviews and inspections were conducted with 13 pesticides importing companies made up of nine indigenous and four foreign companies selected in Accra and Kumasi. These companies had been selected based on their preparedness to respond to questionnaires of the team and to allow their outfits to be inspected.

Their simple task was to indicate and show to the team whether their outfits had been inspected by the EPA during the year of the study, whether they had valid pesticides dealers licence to operate as described in section 40 (1–2) of the Act, whether they were selling registered pesticides (section 28 of Act) and whether the attendants were provided with PPE which were in line with section 44 (4–5).

Fieldwork was conducted on 30 randomly selected pesticides' retailers in Kumasi-Kejetia, which is the main commercial market in Ghana where most of the import, distribution and retail of pesticides occur. A list of licensed pesticides importers, retailer shops and commercial applicators for the country was used to identify their locations for the interview. Since pesticides are special products under the pesticides law, having the license or not was considered vital for accessing the actors, but the status of licences was noted. The survey was conducted from May 2013 to January 2014 at seven sites comprising of six irrigation sites from five regions and one plantation area for the farmers. These were the Okyereko (OK) irrigation site (25 respondents) in the Central region, the Weija (WJ) and the Ashaiman (AS) irrigation sites (25 respondents) each in the Greater Accra Region, the Akuse (AK) irrigation site (25 respondents) and cocoa plantations in New Tafo Akim/Tontro (TN) (31 respondents), the Eastern region, the Akomadan (AD) irrigation site (14 respondents) in the Ashanti region and the Tono (TO) irrigation site (11 respondents) in the Upper East region. The study sites were chosen to reflect the increasing importance of farming in the country and where pesticides are used intensively. These regions were selected as representative of Ghana in terms of economic prosperity, agricultural advancement, crops grown, geography and climate among others (Dickson and Benneh 1977; MOFA 2011). Crops grown in OK and AS included vegetables (tomato, pepper, onion, okro, garden eggs, cabbage, cucumber, tinda, cowpea, soybean, lettuce, groundnut) and rice, while vegetables were grown in WJ, AD and TO, rice in AK and cocoa in TN.

A questionnaire was pretested in the field on some farmers. The focus was on farmers' understanding of agricultural pesticides used, possible risks for human beings and the environment when pesticides are used. This allowed for corrections and adjustments to the questionnaire before the final survey. Other information required included the pesticides used, their purity and used dosages, time of application and poisoning symptoms. Information on the use of protective clothing by farmers while using pesticides was also obtained. The source of information for farmers on new and banned pesticides was noted. Farmers were also asked whether they have been screened for pesticide poisoning. Data were subsequently collected by completing the questionnaire during semi-structured (personal and group) interviews and discussions (in English and local dialects) with local farmers. At least one agrochemical dealer in each site was also interviewed concerning pesticides usage and safety. The registration status of the identified pesticides used by farmers in Ghana was determined from the registration authorities (Environmental Protection Agency, Ghana).

Prior informed consent from each respondent was gained and permission to carry out research at the sites was obtained from the scheme managers of the irrigation sites and from the owners of cocoa farms. A total of 156 farmers voluntarily responded to the questionnaire in the survey. We also observed farmers' practices as they work to validate some of the questionnaire-based data because most interviews were conducted when farmers were working in the field. Further interviews were conducted with a total of 15 extension staff (local state actors) in the course of data collection with the farmers. These interviews centred on the problems they encounter in the running of their daily activities with respect to their access to information, the available resources and their motivation while working with the farmers. It involved 18 questions (10 questions on motivation, three on resource and five on information).

A second survey included a total of 17 extensive interviews with national state actors (policy implementers). They included nine pesticides registration experts from the Ghana EPA, and five persons from the PPRSD. The interview focused on the pesticides policy implementation, the registration process, pesticides inspections and pesticides quality control and available observation in terms of information, motivation and resources. Discussions were also held with the Poison Control Center (PCC) of the Ministry of Health (MoH) on pesticides poisoning related issues. Two officers of the Customs Division of the Ghana Revenue Authority (GRA) were interviewed on import and export controls, access to information, resources, and their motivation. For this, a questionnaire containing 21 questions (motivation 10, resource 5 and information 6 questions) regarding available observation in the implementation process was used. In addition, results of secondary data collected from the registration authority in Ghana were used to verify the authenticity of the findings of the pesticides law (Part II of Act 490 1994).

The response for the non-state policy actors were mostly "yes" or "no", and the results were presented as percentages. Bivariate analysis using the Chi-square was used to determine statistically significant associations between the demographic characteristic and farmers' knowledge, attitude, and practices; then multi-criteria statistical cluster analyses were used for responses of the national state policy actors' (Ghana EPA and PPRSD on pesticide governance). The respondents had the task of assigning a grade of between 1 and 5 (1: insignificant, 2: quite insignificant, 3: significant, 4: very significant, 5: most significant) to a particular question. Analysis of the data accepts the general knowledge that state policy actors responded to the same questions regarding the implementation of the policy. The answers to the questions provide ordinal qualitative variables, yielding a classic multidimensional matrix consisting of objects (policy implementer) and question which has an attribute referred to as observation in the form of either a motivation, information or resource question). Responses obtained for particular question form clusters which are mutually interdependent. The clusters are formed using a hierarchical agglomeration procedure, which progressively clusters groups of elements, starting with the grouping of the most similar ones and, in the following steps, group less similar clusters.

The analysis identifies groups with similar compositions of needs to define possible solution options (remediations) based on similarities between the responses to the main question. SPSS statistical software (version 21.0) was used for all the analyses.

3 Results and discussion

3.1 Non-state policy actors of pesticides

3.1.1 Farmers' pesticides use practices

Table 1 shows the summary statistics of the demographic characteristics of the respondents. Out of the total of 156 farmers that were given questionnaire, all questionnaires were filled and returned given a response rate 100%. Almost all of the farmers interviewed were males. The mean age was 32 ± 1.6 years, and those aged more than 50 years formed the majority among the respondents. Majority had worked for a period between 10 and 20 years representing 42.7% of the respondent's and 58.3% had some form of basic education.

Table 1 Demographic characteristics of respondents

Variable	Frequency ($N=156$)	Percentage
Age (years)		
18–35	50	32.1
36–50	48	30.8
> 50	58	37.2
Educational level		
No formal education	49	31.4
Basic	91	58.3
Secondary	13	8.3
College	3	1.9
Duration of work (years)		
< 10	34	21.8
10–20	67	42.9
21–30	20	12.8
> 30	10	6.4
Stagger planting	25	16.0

All interviewed farmers sprayed their crops with a pesticide to control pests and diseases, an observation which is shared by Ntow et al. (2006). Dinham (2003) estimated that 87% of Ghana vegetable farmers use chemical pesticides for pest and disease control. Thirty-three different pesticide products made up from different active ingredients from the combined study sites were recorded. Table 2 shows the products with their applied doses, recommended doses, active ingredient concentration and their groupings. These included 36% insecticides, 30% fungicides, 30% herbicides and 4% nematicides. All the used pesticides had been registered for use (Table S2) in compliance with section 28 (1) of the Act. This is an improvement from a decade ago, since Ntow et al. (2006) found in a similar study that 47% of the used pesticides were not registered. Our findings are in line with Ngowi et al. (2001) who reported that insecticides are predominantly used for vegetables in Tanzania. However, a pesticide registered to control fungi pest on cocoa, i.e. Kocide (Copper hydroxide), was found in Weija being used for fungi pest on vegetables. This finding is consistent with a study by Amoako et al. (2012) who mentioned Kocide as a product used for the cultivation of vegetables (cabbage) in Ghana and in violation of section 44 (1) of the Act. Figure 2 presents a summary of sources of pesticides imports into Ghana per the label information during the field study. These were subsequently verified on Ghana's pesticides register of the Environmental Protection Agency. The verification confirmed the products as registered and derived from authentic sources satisfying section 38 of the pesticides act. The identified products are therefore not likely to pose problems with regard to faking and adulteration.

From the first empirical survey, information on the safe handling and use of pesticides appears to be limitedly available to the farmers. Seventeen pesticides were overdosed (Table 3), an assertion described by several other earlier studies (Clarke et al. 1997; Mensah et al. 2002 and Ntow 1998), but recent studies are missing. Our results show that pesticides use by this category of respondents are a direct contravention of section 44 (1) of the Act. Some of the farmers attributed the reason to overdose to the presence of dew on the leaves of plants especially during the mornings. As a result, they usually increase the

Table 2 Synthetic pesticides recorded in the study and approved by the Environmental Protection Agency of Ghana to control the most important pests in agriculture including their active ingredients, purity, applied and recommended dosages

Active ingredient	Active ingredient conc.	Group	Applied dose, l/ha, kg/ha	Recommended dose on label, l/ha, kg/ha
Herbicide				
*Glyphosate	360 g/L 480 g/L	Phosphonate	1.2–9.8 L	0.5–2.5 L
*Paraquat	200 g/L	Bipiridillium	1.5–8.33 L	1.5–3.0 L
*Butachlor	500 g/L	Acetanilide	6.67 L	4.0 L
*Pendimethalin	400 g/L	Dinitroaniline	3.0–9.8 L	2.5–3.0 L
Propanil	360 g/L	Acetanilide	2.0–3.7 L	8.0–10 L
*Bensulfuron methyl	30%	Sulfonylurea	0.42 kg	0.003–0.10 kg
*Bispyribac sodium	400 g/L	Pyrimidinyl oxybenzoic acid	0.10 L	0.015–0.05 L
Propanil + 2, 4-D	360 g/L + 200 g/L	Acetanilide Phenoxy acid	2.0–3.7 L	4.0 L
*Pretilachlor + Pyribenzoxim	30% + 2%	Chloroacetamide Pyrimidinyl(thio)benzoate	2.0 L	1.0–1.5 L
*Oxyfluorfen + Glyphosate	300 g/L + 360 g/L	Phosphonate	1.5–2.0 L	0.75–0.90 L
Insecticide				
*Lambda Cyhalothrin	25 g/L 50 g/L	Pyrethroid	1.0–14.8 L	0.6 L 0.4 L
*Chlorpyrifos	480 g/L	Organophosphate	1.0–1.67 L	0.6–1.0 L
*Emamectin benzoate	1.9%	Avermectin	0.62–1.85 L	0.25–0.30 L
Imidacloprid	200 g/L	Neonicotinoid	0.15 L	0.6 L
*Lambda cyhalothrin + Acetamiprid	16 g/L + 20 g/L	Pyrethroid Neonicotinoid	1.5 L	1.0 L
Acetamiprid	200 g/L	Neonicotinoid	0.37 L	–
Novaluron	35 g/L	Insect growth regulator	0.45 L	–
Thiamethoxam	240 g/L	Neonicotinoid	0.125–0.150 L	0.125–0.150 L
Bifenthrin	27 g/L	Pyrethroid	0.50 L	

Table 2 (continued)

Active ingredient	Active ingredient conc.	Group	Applied dose, l/ha, kg/ha	Recommended dose on label, l/ha, kg/ha
*Cypermethrin + Dimethoate	36 g/L + 400 g/L	Pyrethroid Carbamate	2.5–9.8 L	0.5 L
Bifenthrin + Novaluron	30 g/L 35 g/L	Pyrethroid IGR	0.45 L	–
Bifenthrin + Acetamiprid	30 g/L 16 g/L	Pyrethroid Neonicotinoid	0.055–0.075 L	–
Nematicide				
Carbofuran	3%	Carbamate	0.6 kg	20–25 kg
Fungicide				
*Mancozeb	800 g/kg	Dithiocarbamate	5.93–9.88 kg	0.8–2.0 kg
*Carbendazim	500 g/kg	Benzimidazole carbamate	0.8–1.6 kg	0.13–0.26 kg
*Sulphur	800 g/kg		0.8–0.988 kg	0.67 kg
*Maneb	800 g/kg	Ethylene bisdithiocarbamate	9.88 kg	2.0–4.0 kg
Copper hydroxide	77%		0.74–1.5 kg	2.0–4.0 kg
Metalaxyl + Mancozeb	8% + 64%	Phenylamide	1.0 kg	2.0–2.5 kg
Metalaxyl-M + cuprous oxide	12% + 60%	Phenylamide	0.25–4.94 kg	1.0 kg
Cuprous oxide nordox	86%	–	0.15 kg	–
Cupric hydroxide	53.8%	–	0.8 kg	–
Copper + metalaxyl	35% + 15%	Phenylamide	0.75 kg	–

(*) Pesticide Products that showed over dosing in their application

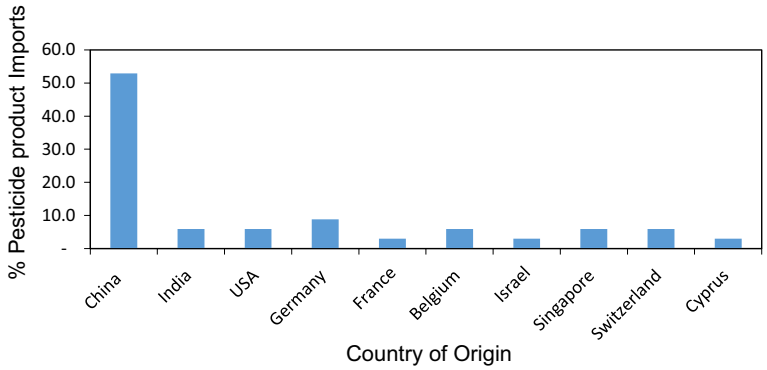

Fig. 2 Sources of pesticide imports into Ghana

volume of pesticides product to apply. In their estimation, this could compensate for the excess water on the leaves, and this is likely to contribute to the overdosing. This assertion needs attention and the necessary corrective intervention by state policy implementers.

Farmers indicated that they mix the pesticides close to the rivers, streams and canals (Table 4). All the interviewed farmers indicated that they cleaned their spraying equipment after pesticides use by rinsing with water, and that canals and drains have sometimes been compromised by emptying the rinse water into nearby water bodies. Practices of mixing pesticides and washing tanks near and in the river as well as throwing pesticide containers after use in the river or forests are posing environmental risk to aquatic organisms.

The possible environmental risks have been demonstrated in other studies by Ramo et al. (2016) and Teklu et al. (2016) in Costa Rica and Ethiopia, respectively. There is, therefore, a need to perform environmental risk assessments of current pesticides use in Ghana to identify pesticides that pose the highest risks to the aquatic environment and to determine threshold levels of the pesticides that are protective of the environment.

The data indicated that accidental spills took place in the field during pesticides application as a result of inferior equipment (82%), when removing pressurized tubes and nozzles due to strong winds (together 17%), while one farmer reported of an accidental spill during mixing (Table 4). Farmers are probably the actors having the greatest risk of pesticides poisoning due to their intimate contact with pesticides. Ntow et al. (2006) found that knapsack sprayer is prone to leakage, especially when it is getting old. Matthews et al. (2003) emphasizes the need to provide better-quality, affordable and comfortable equipment.

A couple of farmers (15%) wash themselves after accidentally being exposed to pesticides, while others (5%) changed clothing before and after pesticides exposure, while the remaining farmers did not do anything (Table 4). This lack of adherence to strict safety measures under section 44 (4) of the Act could lead to different health problems.

Interviewed farmers indicate that they get most information and updates regarding the pesticides usage and safety, banned pesticides including new methods of pesticide application, through extension staff (Table 5). Interactions with the farmers revealed that information from the registration authorities is not disseminated easily to the farmers and information on the status of pesticides is not regularly published. It is expected that the registration authorities would seriously engage the services and expertise of the extension staff to disseminate information to the farmers a view shared by Ngowi et al. (2007).

Table 3 Synthetic pesticides recorded in the study, which were overdosed pesticides as well as the sites where the overdosing took place

Pesticide class	Active ingredient(s)	Applied dose, l/ha, kg/ha		Recommended dose on label, l/ha, kg/ha		Site(s)
		Range	Median	Range	Median	
Herbicide	Glyphosate	1.2–9.8 L	5.5 L	0.5–2.5 L	3.0 L	AS
	Paraquat	1.5–8.33 L	4.9 L	1.5–3.0 L	2.25 L	AS
	Bensulfuron methyl	0.42 kg	–	0.003–0.10 kg	0.05 kg	AS, OK, AK
	Pretilachlor + Pyribenzoxim	2.0 L	–	1.0–1.5 L	1.25 L	AK
	Oxyfluorfen + Glyphosate	1.5–2.0 L	1.75 L	0.75–0.90 L	0.83 L	WJ
	Pendimethalin	3.0–9.8 L	6.4 L	2.5–3.0 L	4.0 L	AS, AK
	Bispyribac sodium	0.10 L	–	0.015–0.05 L	0.03 L	AK
	Butachlor	6.67 L	–	4.0 L	–	OK
Insecticide	Lambda Cyhalothrin	1.0–14.8 L	7.9 L	0.4–0.6 L	0.5 L	AS, OK, WJ, AK
	Emamectin benzoate	0.62–1.85 L	1.24 L	0.25–0.30 L	0.28 L	AS, OK, WJ
	Lambda Cyhalothrin + Acetamiprid	1.5 L	–	1.0 L	–	OK
	Cypermethrin + Dimethoate	2.5–9.8 L	6.15 L	0.5 L	–	AS, OK
	Chlorpyrifos	1.0–1.67 L	1.33 L	0.6–1.0 L	1.1 L	AS, OK, WJ, AK
Fungicide	Mancozeb	5.93–9.88 kg	7.9 kg	0.8–2.0 kg	1.4 kg	AS, WJ, OK
	Carbendazim	0.8–1.6 kg	1.2 kg	0.130–0.260 kg	0.2 kg	WJ
	Sulphur	0.8–0.988 kg	0.89 kg	0.67 kg	–	AS, AK
	Maneb	9.88 kg	–	2.0–4.0 kg	2.0 kg	WJ, AS

NB: AS Ashaiman, AK Akuse, WJ Weija, OK Okyereko, TN Tontro

Table 4 Questions on farmers and sprayers knowledge, attitude, practices during pesticide use and occurrence of recent spills ($n=156$)

Question	Yes	Percentage
(a) Have you ever spilt pesticide mix on your body while working		
i. Because of improper fitted lid	142	91
ii. During Pouring, loading	141	90
iii. Wrong wind direction	156	100
iv. Leaking equipment	156	100
v. Falling in the field	156	100
vi. Wrong movement with the sprayer	156	100
vii. Spray above the body	156	100
(b) How can you help a colleague during pesticide splash		
i. Advice washing	156	100
ii. Go to health centre	156	100
iii. Advice drink water	0	0
iv. Advice drink red palm oil	0	0
v. No problem, no idea	0	0
(c) What protective measure did you take to protect yourself at your last spray operation		
i. Wore overall	0	0
ii. Wore safety shoe	25	16
iii. Used respirator	4	3
iv. Used gloves	0	0
v. Used goggles	0	0
vi. Used apron	0	0
vii. Used a hat	0	0
viii. Practiced careful working	156	100
ix. Timed the spraying, e.g. early morning	156	100
(d) What did you do during and after spraying the pesticide		
i. Wash your hands after spraying?	156	100
ii. Eat/drink/smoke during work with pesticides	12	8
iii. Keep meals near pesticides?	0	0
iv. Drink water near pesticide-treated fields	0	0
v. Shower after pesticide exposure	24	15
vi. Change clothing before and after pesticide exposure	7	5
(e) Where do you prepare pesticide mix for application		
i. Chemical store	0	0
ii. Outdoors	0	0
iii. Close to dam/river/stream	156	100
iv. In the house	0	0
v. Wherever	0	0
(f) How did the most recent accidental spill that you experienced take place?		
i. While mixing (Accidental)	1	1
ii. During preparation for spraying	0	0
iii. Inferior equipment	128	82
iv. While storing	0	0
v. Other (strong wind)	27	17
(g) Have you ever been screened for pesticide poisoning before?	0	0

Table 5 Questions on information on pesticide usage and safety, banned pesticides and new methods of application ($n = 156$)

Item	Yes	Percentage
Pesticides usage and safety		
Extension staff	120	77
Labels	17	11
Consultants	19	12
Banned pesticides		
Extension staff	115	74
Consultants	19	12
Meetings	13	8
Farmer's Association	9	6
New methods of pesticide application		
Extension staff	115	74
Consultants	19	12
Meetings	11	7
Farmers' Association	11	7

The survey showed that the interviewed farmers have had some form of training on pesticide application and safety. Most of the knowledge and expertise acquired was from formal advice (90%) and through training on the job. Additionally, extension staff and consultants who promote their pesticides were also involved (Table 5).

Generally, none of the farmers had recorded any pesticide spill on their body as a result of wrong wind direction, leaking equipment, falling in the field, wrong movement with the sprayer or spraying above the body. However, 90% of farmers admitted spill during pouring and loading of spray equipment, suggesting the need for special attention on the correct and appropriate means of pouring and loading spray equipment in subsequent training sections. Farmers had ample knowledge on how to help a colleague in the event of pesticide splash, and apart from safety shoes and respirators, no respondent had used protective measures, i.e. personal protective equipment (PPE), to protect them during their spray operations (Table 4). Other studies have also shown that protective actions using PPE's are rarely taken while handling and applying pesticides (Berg 2001; Matthews et al. 2003; Perry et al. 2002). Wilson and Tisdell (2001) reports that protective clothing has not been used enough particularly in less-developed countries. A lack of money to buy them and the absence of (enforcement of) regulations on their use are posed as the most important reasons for this. However, in Ghana, this is a clear violation of section 44 (1, 2 and 4) of the pesticides Act. In the survey, farmers complain of the cost of PPEs and the fact that it is uncomfortable to use. Ntow et al. (2006) reported similar findings that the PPEs are hardly used by Ghanaian farmers because of discomfort associated with the hot and humid weather and their costs. However, there is the urgent need for farmers' attention to be drawn to the usefulness of the PPEs through practical demonstrations by extension staff. Okoffo et al. (2016) reported that the influence of extension service on the use of PPE is significant enough to strengthen it in order to increase farmers' knowledge and awareness of the consequences of applying pesticides without PPE. The study showed that the age of farmers had a significant influence on their knowledge about the use of pesticides. A bivariate analysis using the Chi-square revealed statistically significant associations between age and knowledge variables such as; the use of improper fitted lid, identification of wrong wind direction during spraying, knowledge during pouring and loading of pesticides as

well as wrong movement during spraying of pesticides ($\chi^2 = 32.236$, $P < 0.001$). There was also significant association between educational level attained and knowledge ($\chi^2 = 3.614$; $P \leq 0.05$). Work experience or duration of farming also significantly influenced the knowledge of respondents ($P < 0.001$).

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The study further revealed statistically significant associations between age and practice, such as the washing of hands after spraying, eat/drink or smoke during working with pesticides, keep meals near pesticides, drinking water near pesticide-treated fields, shower after pesticides exposure and changing of clothing immediately after pesticide exposure ($P < 0.001$). There was significant association between educational level attained and farm management practices ($P < 0.05$). Work experience or duration of farming was significantly associated with farm management practices at 5% level of significance ($P \leq 0.05$).

Interactions with the farmers revealed that they are not conversant with the pesticides law and the provisions in it to safeguard them and the environment. The registration authorities in collaboration with the extension services educate the farmers at their meetings of their roles and responsibilities regarding the pesticides law, its provisions and penalties especially sections 44 and 56–62. The behaviour and action of farmers have been motivated by certain factors that pertain to their setting and circumstances. Interviewed farmers indicated that 76% of them use products immediately, while 24% use the products within a month. Storage is limited since sales outlets are within reach of the communities, the farms are small and finances are limited. The decrease in the time of storage for the use of the products is encouraging, as the likelihood of exposure to the pesticides and related ill effects are reduced, since most farmers store pesticides in their house but not in bedrooms (89%). Five percent of the respondents keep it somewhere on the farm for later use. 2 and 4% of the farmers stored the pesticides in their general stores and bedrooms, respectively. Storing pesticides in the homes and bedrooms for long durations can lead to exposure and risk of intoxication (Clarke et al. 1997). Kimani and Mwanthi (1995), Murphy et al. (2002) and Ngowi et al. (2001) report that it is very common in many developing countries to store pesticides at unguarded places in their homes. In the upper East region of Ghana, 15 farmers died in 2010 which were attributed to pesticides poisoning, mostly related to poor storage of pesticides (The Northern Presbyterian Agricultural Services and Partners 2012). Seventy percent of the farmers purchase pesticides from local dealers/retailers, while 6% obtained the products from importers/local agents in the cities. Those who purchased them from consultants of the importing companies were 4%, and remaining were those involved in the governments mass spraying exercise in Tontro site (20%).

Seventy percent of the farmers used rate of applications, recommended by supplier, retailer or dealer. This was followed by the recommended application rate or frequency on the packaging label, and those who used their own application rate and frequency (Table 6). This may be a result of the direct contact between the suppliers and the farmers and the resulting ease to convince them. Ntow et al. (2006), however, reports Agricultural Extension Officers and/or pesticide labels as main source of information on pesticides application rates.

Table 6 Questions on skills and knowledge for storage of pesticide and use of recommended application of pesticides ($n = 156$)

Item	Yes	Percentage
Skills and knowledge of storage		
Stored in the house, not bedroom	138	89
Somewhere on the farm for later use	9	5
Store pesticides in general stores	3	2
Store in the house, bedroom	6	4
Recommended application		
Label recommendation	41	26
Supplier recommendation	109	70
Own recommendation	6	4

With regard to choice of using a pesticide (Table 7), seasonal occurrence of pest (45%) especially during land preparation (weed control) was the most important factor followed by preventive reasons (15%), pest density control (8%), curative factors (4%), weather factors and defensive related use (3%) each and routine application (22%). Amoako et al. (2012), however, conducted a similar study in Ashanti region of Ghana and reported a contrary observation, i.e. that choosing for a particular pesticides was based on its availability on market in their area of operation, its price and its efficacy for insect pests. From the result, it is important to encourage farmers to use pesticides only when necessary as anticipated pest occurrence and pesticides application may lead to problems of pest resistance, environmental pollution, and occupational exposure among others (Metacalf 1980; Ngowi et al. 2001; Ramo et al. 2016). The pesticides use and frequency by farmers are provided in Table S1.

Most farmers mentioned during the discussion that pesticides are necessary, but are open and willing to use appropriate alternative methods of pest control if they became available, effective and affordable. Farmers mentioned health problems like headaches, burning sensation in the eyes, itching and skin irritation, among others (Table 8). Pesticides exposure may result in physical and mental illnesses such as dermatitis, anxiety, irritability, loss of memory and depression, which ultimately may result in suicide (Kishi et al. 1995; Harris 2000; Koh and Jeyaratnam 1996). It is estimated that worldwide 3 million people are affected by pesticides poisoning annually, resulting in 220,000 deaths (Konradsen et al. 2003). The situation calls for immediate attention for necessary solution options from the authorities. The farmers also remarked that they have not been screened specifically for pesticides poisoning before (Table 4), and therefore were prepared to subject themselves to be screened for pesticides exposure/poisoning if the opportunity is made available.

Table 7 Decision for selection of pesticide for use ($n = 156$)

Item	Yes	Percentage
Seasonal occurrence of pest	70	45
Preventive reasons	23	15
Pest density control	12	8
Curative factors	6	4
Weather factors,	5	3
Defensive related use	5	3
Routine application	34	22

Table 8 Have you experienced any of the listed symptoms following pesticide application? ($n = 156$)

Symptom	Yes	Percentage
Headache	156	100
Burning sensation in eyes/face	156	100
Fever	146	94
Watering eye	156	100
Skin rash	142	91
Itching and skin irritation	156	100
Dizziness	154	99
Cold, breathlessness and/or chest pain	122	78
Forgetfulness	136	87
Loss of libido	83	53
Salivation and vomiting	110	71
Abdominal pain/diarrhoea	117	75
Weakness	156	100

3.1.2 Pesticides import, distribution and retail

The involvement of private actors in importation, distribution and retailing of pesticide products in Ghana has been phenomenal since the introduction of the pesticides law. Currently, the pesticides distribution in Ghana is performed by many small-scale private businesses and their number increased from 515 in 2010 to 916 in 2011 (Source, Office of the Pesticides Registrar, Ghana EPA). Following the introduction of the law, 441 pesticides had been registered as at December 2014 for agricultural and household uses by the EPA. The registered pesticides included 47% insecticides, 12% fungicides, 37% herbicides, 1% plant growth regulators, and 1% (molluscicides, rodenticides, nematicides and adjuvants). It is on record that the number of registered pesticides increased from 2003 to 2011 (Fig. 3), while the volume of imported pesticide products was an average of 9216 tons

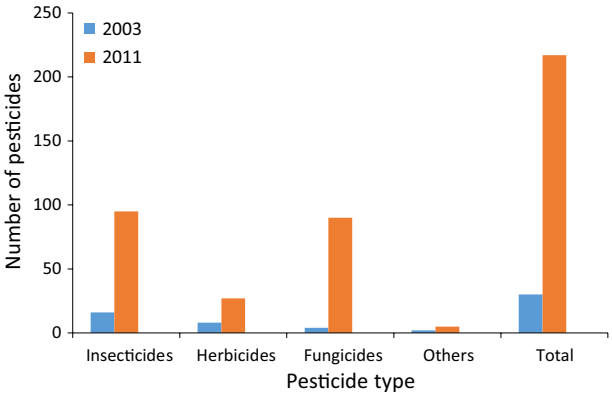

Fig. 3 Number of formulated pesticide products registered or provisionally cleared in 2003 and 2011. *Source*: Environmental Protection Agency-Ghana, Annual Reports, Accra. "Other" includes rodenticides, nematicides, fumigants and other conventional pesticides, and other chemicals used as pesticides such as petroleum oil

of insecticides, 8986 tons of herbicides and 2545 tons of fungicides from 2004 to 2015 (Table S3).

It is worth mentioning that currently there is no pesticides manufacturing and formulation plants in Ghana, and all pesticide products are imported (Fig. 2). The rapid increase in the amount of pesticide companies and retailers shows the lucrative nature of the pesticides business in Ghana. The motivation is the profit on sales as the interaction revealed. Empirical findings of this study showed that all the visited distributors had valid licences to operate and pesticides registration permits for the displayed pesticide products (Table 9).

The displayed products were not expired (Table 9). This was to be expected as their ability to import pesticide products are tied into the renewal of licenses. However, 23% of the retail outlets had their licenses expired or in the process of being renewed in violation of section 40 (1) of the Act. Similar observations were made regarding their knowledge of the pesticides law, as their appreciation of it was generally inadequate. The distributors and retailers violated section 44 (4 and 5) of the Act. The provision and use of PPEs as well as the technical knowledge on the handling of pesticides by retailers was low (Table 9).

The observation suggests the probable shortage of expert advice and technical support on pesticides for farmers who may patronize these shops leading to problems of indiscriminate use, high frequency of application and application of pesticides with the same mode of action which may lead to pest resistance and resurgence and associated indirect costs. Gill and Garg (2014) discussed other potential management options including cultural and physical control, host plant resistance, biocontrol, and the use of biopesticides. Although

Table 9 Compliance to Pesticide Registration Licence by pesticide dealers

Question	Yes	Percentage
(a) Has this place been inspected by the EPA/PPRSD (2014/15)?		
Importer/distributor ($n=13$)	13	100
Pesticide retailer ($n=30$)	30	100
(b) Has the activity been licensed by the EPA		
Importer/Distributor ($n=13$)	13	100
Pesticide Retailer ($n=30$)	23	77
(c) Technical Know-how/Use of PPEs		
Importer/distributor		
i. Know the Pesticide Law	13	100
ii. Do you have the current pesticide registration list (Dec. 2014)?	7	54
iii. Knowledge/skill to identify symptoms of pest attack?	13	100
iv. Technical Knowledge on field diagnosis of pest?	13	100
v. Know the different pesticide application methods?	13	100
vi. Use of PPE	3	23
Retailer		
i. Know the Pesticide Law	30	100
ii. Do you have the current pesticide registration list (Dec. 2014)?	0	0
iii. Knowledge/skill to identify symptoms of pest attack?	5	17
iv. Technical Knowledge on field diagnosis of pest?	6	20
v. Know the different pesticide application methods?	26	87
vi. Use of PPE	11	37

having limited knowledge, many farmers still prefer to contact a pesticides retailer instead of an extension official when problems arise, because of their close proximity. Mengistie et al. (2014) reported a similar trend for seeking for information by farmers in Ethiopia. Discussion with owners of the shops indicated that most of their recruited staff upon successful training in pesticides management resign to either establish their own businesses or join companies with better remunerations. However, since the level of know-how of the retailers needs further improvement, rigorous information dissemination by the extension service is required.

3.2 State policy actors of pesticides

The state policy actors of pesticides was considered at national (Ghana EPA and PPRSD) and local (extension staff) levels. The state actors are important to transfer knowledge to importers, distributors/retailers and farmers and to increase the implementation of policy at both the national and the local (farm) level.

3.2.1 National state actors

The ranked score gave an indication of how the issues questioned on (motivation, information and resources) had performed and showed those that had been achieved, those in-between and those that had underperformed and needed attention. This defines the strong and weak aspects of the implementation process. It is clear that—"salary" and "transport facilities are adequate to access pesticides dealers and users" are the least scored. This indicates the need of state policy implementers for improvements in salaries and means to reach pesticides distributors, retailers and farmers. Among the most strong aspects in the implementation process investigated were "knowledge of the pesticides law", "current pesticides register", "pesticides registration process", "different pesticide application methods", and "work being interesting" (Table 10).

Figure 4 shows the available observation criteria for state policy implementers in policy implementation hierarchical cluster. The tree diagram depicts the result of the cluster analyses of 21 mutually dependent questions and attributes (referred to as observation—motivation (M), information (I) and resource (R) shown in Table S3) and responses for the cluster represents people who share similar concerns and characteristics.

The first cluster (most left) are state policy actors who know the pesticides law, have the current pesticides registration list, are familiar with the pesticides registration process, know the different pesticides application methods, have knowledge/skill to identify symptoms of pest attack, have technical knowledge on the diagnosis of pest in the field, find the work itself interesting, and are satisfied with their current job. These people find their work to be the most significant contributor to their motivation. Motivation, resources and information are significant to achieving their required job. This cluster can be described as the work result recognition group (Zámečník 2014).

The second cluster (middle) concerns the relation between management and employees, technical staff for risk assessment of submitted pesticide dossiers, in-service training and skills development on current job satisfaction, sufficient space to work, pesticide user manuals are available to be effectively used by pesticide dealers, and carrier structure and promotion on current job satisfaction. To a large extent, the second cluster is linked to the first cluster, and motivation and resources are significant to achieving this required job.

Table 10 Ranking of responses to questions and related observation ($n = 17$)

Rank	Motivation (M)/resource (R)/information (I)	Observation	Sum of responses
1	Know the Pesticide Law	I	85
1	Do you have the current pesticide registration list (Dec. 2014)	I	85
1	Familiar with the pesticide registration process?	I	85
4	Know the different pesticide application methods?	I	79
4	Work itself interesting	M	79
6	Current Job is satisfactory	M	77
7	Knowledge/skill to identify symptoms of pest attack?	I	75
7	Technical Knowledge on field diagnosis of pest?	I	75
9	Job security	M	66
10	The relation between management and employees	M	64
11	Technical staff for risk assessment of submitted pesticide dossiers?	R	59
12	In-service training and skills development on current job satisfaction	M	56
13	Sufficient space to work	M	51
14	Pesticide user manuals are available to be effectively used by pesticide dealers	R	49
15	Accredited laboratory to test pesticide products?	R	44
16	Carrier structure and promotion on current job satisfactory	M	34
17	Recognition, rewards, praise by supervisors	M	32
18	Financial benefits and bonuses	M	30
18	No. of pesticide inspectors assigned to dealers and users of pesticides proportional?	R	30
21	Salary is encouraging	M	21
21	Transport facilities are adequate to access pesticide dealers and users?	R	21

Motivation = M; resource = R; information = I

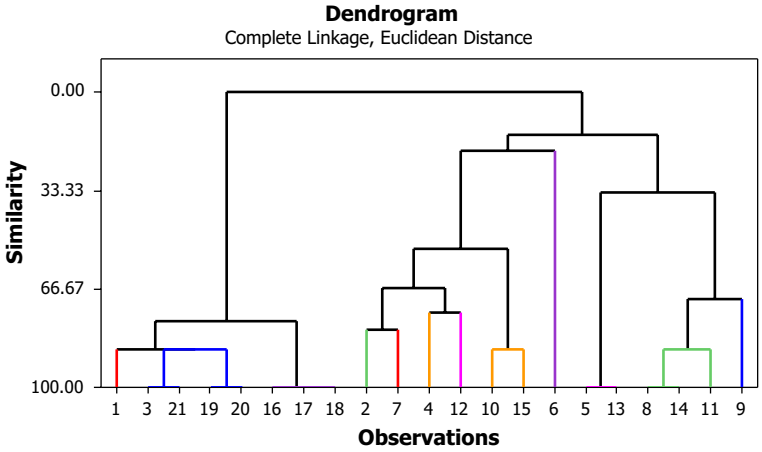

Fig. 4 Diagram showing hierarchical cluster of observation [motivation (1–10), resources (11–15), and information (16–21)] by policy implementers

The third cluster (most right) is composed of accredited laboratory to test pesticide products, recognition of actors input to achieving results by management, rewards and praise by supervisors for success, financial benefits and bonuses, number of pesticide inspectors assigned to dealers and users of pesticides proportional, unattractive salary, lack of transport facilities to adequately access pesticide dealers and users. In a similar study by Mengistie et al. (2014) in Ethiopia, majority of the actors indicated that they were underpaid given their workload. This cluster can be called the materialistic cluster since motivation and resources are significant to achieving their required job, and these are the main factors undermining the proper implementation of the pesticide registration policy (Zámečník 2014).

3.2.2 Local state actors

Respondents were motivated with high scores regarding security of job (100%), interested in what they do, and that the job was satisfactory (Table 11). Salary, financial benefits, bonuses and recognition for work done by supervisors, however, was low. Access to information was considered adequate with respect to the pesticide law, knowledge and skills to identify symptoms of pest attack, diagnosis and the different pesticide application methods. Lessons drawn from Ntow et al. 2006 point to the importance of agricultural extension officer's involvement in farmers' knowledge of insecticide application. The exception

Table 11 Responses of state actors at local level ($n = 15$)

Item	Yes	Percentage
(A) Motivation		
i. Current job is satisfactory	12	80
ii. In service training and skills development on current job satisfaction	9	60
iii. Work itself interesting	13	86
iv. Carrier structure and promotion on current job satisfaction	11	73
v. Salary is encouraging	3	20
vi. Job security	15	100
vii. The relation between management and employees	9	60
viii. Financial benefits and bonuses	3	20
ix. Recognition, rewards, praise by supervisors	3	20
x. Sufficient space to work	10	66
(B) Resource		
i. Transport facilities are adequate to access pesticide dealers and users?	5	33
ii. No. of pesticide inspectors/extension assigned to dealers and users of pesticides proportional?	0	0
iii. Pesticide user manuals are available to be effectively used by pesticide dealers and farmers?	11	73
(C) Information		
i. Know the Pesticide Law	15	100
ii. Do you have the current pesticide registration list (Dec. 2014)?	8	53
iii. Knowledge/skill to identify symptoms of pest attack?	15	100
iv. Technical Knowledge on field diagnosis of pest?	15	100
v. Know the different pesticide application methods?	15	100

recorded in the study is the unavailability of the pesticides register for 2014. All respondents were of the opinion that the proportion of extension officers to dealers and users of pesticides was low and that there is the lack of transport to easily access the pesticide dealers and users (Table 11).

4 Conclusion

Pesticides legislation on registration and licensing is relatively well developed in Ghana. The study shows a couple of challenges in the policy implementation. These findings have a number of effects on pesticides implementation policy and agricultural sustainability in general. The focus of this study was that policy implementation processes are interaction processes between state actors (policy implementers) and non-state actors (farmers and pesticide dealers, importers, etc.) in relation to attributes as information, motivation and resources. The pesticides policy implementation in Ghana has not been able to adequately deal with the non-state actors such as pesticide dealers with respect to the choice of particular pesticides for a given problem and technical knowledge on field diagnosis of pests and diseases, hence making it difficult to professionally dispense pesticides to farmers including advice on the use of PPEs. Although some farmers are aware of the risks associated with pesticide use, adequate protection provided by PPEs is hardly used. Adequate training on the pesticide handling, use and diagnosis of disease symptoms in the field is required, and more state actors and suppliers are needed to train farmers to rotate the use of chemical pesticide thus reducing the risk of pest resistance. Also, farmers should be encouraged to use their old clothes during preparation and spray operations instead of buying special clothes for spraying, which may be expensive for them. Farmers with a combination of a bit of education and extensive experience identified in study could be used to promote best knowledge, attitude and practices to other farmers. Farmers should also be trained on acute and chronic symptoms of pesticide poisoning and for them to better appreciate the necessary remediative steps to take once they experience such symptoms.

Most importantly, our study reflects the stronger involvement of state actors with the responsibilities to make available to non-state actors various sources of information with regard to pesticides use, management of pesticides and the pesticides law as well as friendly PPE alternatives for farmers through government intervention at subsidized prices. Finally, the pesticides regulations should be passed, and implementers (Ghana EPA/PPRSD) should also be motivated and resourced enough to carry out their mandate in Ghana.

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