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Effect of Agrochemicals on Environment, Health, and Safety: Assessment from Smallholder Farmers Standpoint

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ABSTRACT

Since the era of the Green Revolution, Agricultural production worldwide experienced much efficiency with a remarkable aim to eradicate threats of food insecurity. This breakthrough was anchored on science and technology. Among the interventions this era saw to date were the use of fertilizers and pesticides in our day-to-day farming activity to boost yield and control pests/diseases. The study assessed farmers' knowledge in the use of Agrochemicals given their environmental effects such as on water bodies, occupational hazard and safety, disposal, and storage regarding product use. Questionnaires were administered to farmers cultivating vegetables, food, and cash crops under Open-field and Greenhouse managements in respective Production Specification; Organic and Inorganic productions. The study revealed that 85% of respondents who cultivated cash crops such as Cocoa and Rubber heavily relied on the use of inorganic fertilizers and pesticides. 35.40%, 32.74%, and 19.47% of respondents disposed of Agrochemical containers using Pit burial, Burn/Incinerate, and Indiscriminate methods, respectively, while 12.39% used ecological (biodegradable) materials. 92.7% of the respondents had knowledge about perilous consequence and yet didn't garment recommended protective apparels during application. It was concluded and recommended that the necessity of Agrochemical for pest, disease and weed control were unavoidable in the smallholder farming business in Ghana, despite the gradual rise of inorganic fertilizer and Integrated Pest Management control products. However, needful actions such as Government policy on educational campaign/programs must be intensified. to help appropriately redress misapplications and chemical residue on fresh food produce.

1.0 Introduction

Profitability in smallholder farms is mostly contingent on the use of Agrochemicals with intensity variation depending on the production type (Nyambo *et al.*, 2019). Agrochemicals include several pesticides (Insecticides, herbicides, etc.), Inorganic fertilizers, and disinfectant products (CFSPH, 2010). In Ghana, they are predominantly applied on cash-crop plantations of cocoa, rubber, and oil palm to maximize yield as foreign exchange commodities. Likewise, there is substantial use on root and tubers, cereals and especially, vegetables. The role of inorganic fertilizers that either doubled or tripled crop yield in a short space of time is tremendous and could not be discounted. According to Danielou (2014), half the food we eat today is produced thanks to fertilizers. Agriculture is the core livelihoods of most rural households with increasing availability of inputs such as inorganic fertilizer and manure (Bayite-Kasule, 2009; FAO, 2011; Tittonell *et al.*, 2008) in their rural communities. In crop protection, pesticides enviably provide numerous benefits in weed and insect control. Nonetheless, WHO (2008) reported that when pesticides are applied directly to targeted pests (plant or insect), the whole site is affected, including crops and humans in the immediate area. The process of controlling the pest and disease menace invariably leads to overuse for the most part when the users are not well informed in contrast to the prescribed quantities for application. One of the obvious reasons, according to Nnamonu and Ali (2013) was, for an average farmer, the higher the Agrochemical applied, the higher the yield. Overapplication of Agrochemicals has a great impact on water quality through field runoff (Habib *et al.*, 2017; Zhou *et al.*, 2010). The improper management practices create many problems such as negative externality and deleterious effects on the environment as well as to the human health (both users and bystanders) (Prasannath and Prasannath, 2013; PERSUAP, 2013).

Farmers would resort to applying quantities of Agrochemicals to lessen the insurgence of the pests and diseases on crops, especially as the Ghana horticultural industry was estimated to record about $30 million deficits (Kwofi, 2017) in a chain reaction as far as pesticides are concerned. However, the adoption and continued use are due to exacerbated and unfavorable site conditions on farmlands earmarked with reduced soil fertility, resurgence of pests, and weeds (Nonga *et al.*, 2011). Recently, the strive for epitome related to pests and diseases free fresh Ghanaian Horticultural crops for export resulted in a temporal ban into the European market (Joyce, 2014) due to traces of chemical residues.

Studies have shown that organochlorine residues persist in the food chain and poses cancer risks to humans after consumptions (Braune *et al*. 2005; Colborn, 1993; Jiang et al., 2005; Schwarzenbach *et al*. 2010). These effects on humans in some cases could be a lifelong detriment (Grandjean *et al*. 2008), with the most vulnerable being infants who could suffer from immune function deficits (Van Oostdam *et al*. 2005). These health implications resulting from Agrochemical use on crops are creating an expanding niche for organic crop products.

Among the modern period technological advancement Agriculture has witnessed is Greenhouse farming. Production in Greenhouse in Ghana is on the rise on pilot bases. One of the advantages had been the homogenized systems in place where all parameters for yield performance, such as temperature, light, and water are regulated. Yield levels from Greenhouse are enormously profitable coupled with the high quality of crops/produce, vis-à-vis pest, disease, and weed management as opposed to Open-field production usually under the mercy on natural conditions. Agrochemical applications in Open-fields and Greenhouse production operations vary extensively. Farmers cultivating crops under the Open-field apply with hand tools or, to some extent, by basic mechanization. Whiles in a Greenhouse production, a great deal of fertilizers are applied through irrigation technology such as drip, making it less harmful to farmers during the process. Djibril (2007) confirmed that the Greenhouse Agrochemical application method involves less risk for users due to technology involved but are not affordable by most farmers because of the high level of the initial investment. Therefore, this study sought to assess the use of Agrochemicals on crops (cash, food, and vegetables) in general produced from various regimes of production systems; thus, organic and inorganic and production specification; Open- field and Greenhouse. And to further assess the environment, health, and safety effects in use/application of Agrochemicals from smallholder farmers' perspective.

2.0 Material and Methods

2.1 Study Area

The study was conducted Western Region of Ghana, a territory known for its high contribution to the Agricultural sector especially, with cash crops such as cocoa, rubber, oil palm, and appreciable quantities of vegetable and food crops. Ten (10) communities namely: Asonti, Axim, Asanda in the Nzema East district; Adubrim and Kamgbunli in the Ellembelle district; Ahobre in the Jomoro district; Angu in the Mpohor district; Inchaban in the Shama district; Sekondi college/school in the Sekondi-Takoradi Metropolitan Area and lastly, Tumentu in the Ahanta West district were selected as shown in Fig. 1. The region experiences a bi-modal rainfall pattern and annual temperatures range of 22-35^{0}C.

2.2 Data Collection and Methodology

2.2.1 Sampling Method and Size

Random and purposive sampling techniques were used for data collection and community selection, respectively. The purposive sampling technique was useful due to the interest of Greenhouse infrastructure as there was limited availability in the entire region. Respondents operating under Open fields, however, were randomly selected according to their varying production regimes (organic and inorganic). Questionnaires were pre-tested with 15 respondents for the purpose of ensuring data credibility and efficiency. In total, One hundred and Thirteen (113) closed-ended questionnaires were administered to selected respondents (farmers) with the assistance of well-trained enumerators. SPSS version 16.0 was used for the data analysis.

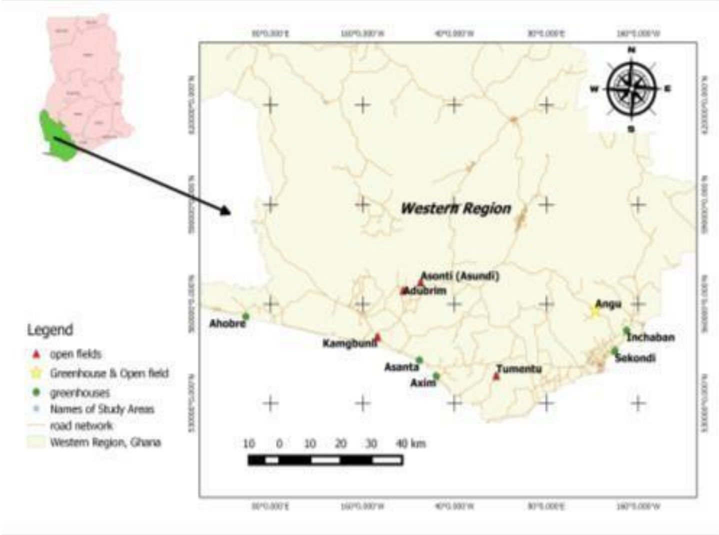

Figure 1. Map of Study Area

3.0 Results and Discussion

3.1 Effect of Agrochemical Use

3.1.1 Health and Safety

Precautions during the application of Agrochemical are crucial as far as essential body organs are concerned and could be considered synonymous with donning of safety gears. Results from the study showed that 37.17% of respondents wore complete safety apparel shown in Fig. 2. However, the majority of the respondents did not comply fully with these standard safety clothing procedures recommended. That is, 42.48% and 20.35% respectively wore usual dresses and partial protective safety apparel as and when handling and application of Agrochemicals on-farm were exercised. Similar findings were made by Afari-Sefa *et al*. (2015) and Ogunjimi and Farinde (2012). Concurrent representation of about 86.73% and 13.27% detoxified essential parts with soapy-water and water only respectively after handling and use of Agrochemicals, as shown in Fig 3. WHO (2008) and PERSUAP (2016) reported that pesticide mode of action is by targeting systems or enzymes in the pests which may be identical or very similar to systems or enzymes in human beings that pose health and environmental risks. Consequential health-related problems Farmers' may be exposed to include redness and tearing of the eye, body itching, cough, body pains, and headache (Ogunjimi and Farinde, 2012).

According to Laary (2012), some farmers who do not usually protect themselves are unaware of the dangers of exposure during handling, formulation, and application of Agrochemicals. However, Users need to wear additional protective equipment as recommended by the label of a chemical such as chemical-resistant gloves, goggles, and/or face shield and an approved respirator (CFSPH, 2010).

The study adopted the classification below for its assessment:

1. **Usual Dressing**: this constituted wearing ordinary clothes with patches of exposed body parts, including feet.
2. **Partial Protective**: involved the use of safety apparel but lacking or with missing of at least one major kit, such as either goggle or nose mask or hand gloves.
3. **Complete Protective**: involved donning all the required and complete kit from head to toe with no obvious body part exposed.

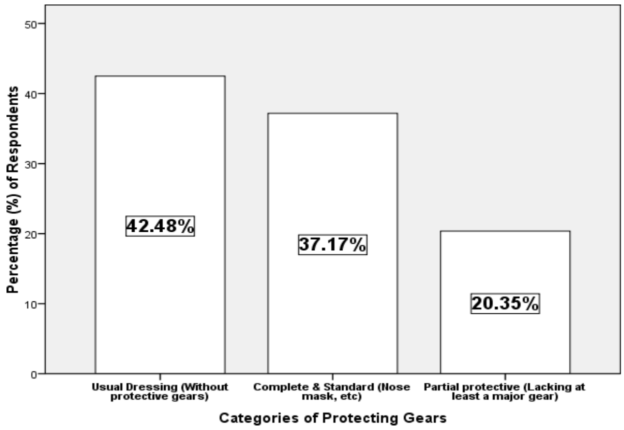

Figure 2. Categories of Safety Apparel Used during Agrochemical Application and Handling

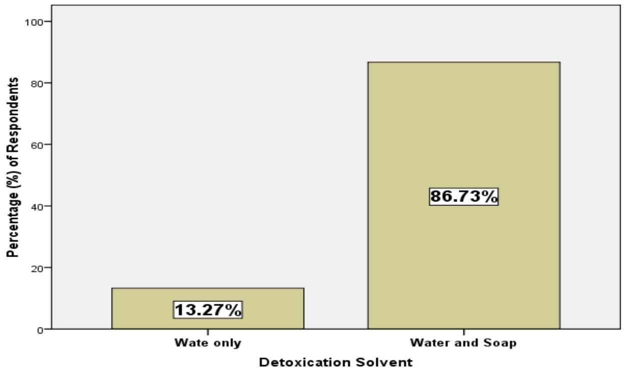

Figure 3. Mode of Detoxification after Agrochemical Use.

3.2 Inspection of Expiry Dates

Inspection of product label details such as expiry dates is very delicate as the composition of content highlights necessary information, especially for Agrochemicals, which are applied to crops. When chemical content expires, the composition becomes altered, rendering it extremely harmful with dangerous implications to human health. The study revealed that 47.79% of respondents satisfactorily checked expiry dates, 24.78% did not check at all, whiles 17.70% did not have the culture of always inspecting Agrochemicals expiry dates as shown in Fig. 4. Although respondents who didn't inspect expiry dates were minimal relative to those who checked, it should be noted that, in real life, such negligence could be devastating to human health. Omari (2014) found a similar outcome.

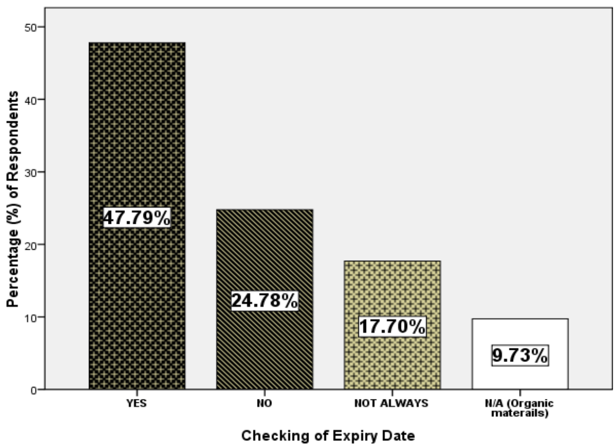

Figure 4. Frequency of Inspecting Expiry dates on Agrochemical Products.

3.3 Effect of Agrochemical Use on Environment

3.3.1 Mode of Container Disposal

The study classified the mode of agrochemical disposal by Pit burial, Burn/incinerate, Indiscriminate, and Biodegradable in relation to the production system (organic and inorganic) and production specification (Open-field and Greenhouse) as shown in Table 1 and Table 3. From the analysis, 35.40%, 32.74%, and 19.47% of respondents resorted to Pit burial, Burn/incinerate, and Indiscriminate container mode of the disposal, respectively, as shown in Fig. 5. Mode of Agrochemical container disposal by farmers was identified as burning, burying in the farm, indiscriminate, reuse, etc. (Sowley and Aforo, 2014). 12.39% of the respondents whose production system was organic used biodegradable material, which was recyclable and ecological in nature.

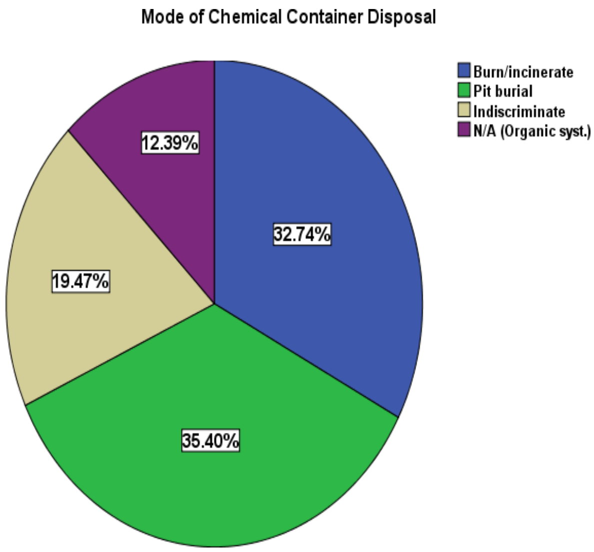

Figure 5. Distribution of Respondents in Chemical Container Disposal.

An indication of 31 (40.3%) of respondents who exercised pit burial disposal mode through their inorganic production system, as shown in Table 1, exclusively proved an important milestone. This demonstrates that perhaps Government and Non-governmental organizations had perhaps made a presence in some of these farming communities to ensure a degree of training in the form of awareness creation towards responsible environmental management. However, those respondents who sometimes practice both Organic and Inorganic (Mixed methods systems) of production practiced much of burning Agrochemical containers in the event of use, as shown in Table 2. An example of a mixed system referred to in this paper could be, a farmer may eradicate weeds with herbicides but strictly use animal manure as fertilizer.

Relatively, respondents operating under Greenhouse showed a break-even (50-50%) in the mode of disposal being pit- burial and incineration, as shown in Table 3. It could be inferred that that was because the nature of Greenhouse production employs conscious sanitation and environment management practices, thus recorded nil for indiscriminate container disposal. According to Afari-Sefa *et al*. (2015), farmers dispose of empty chemical containers by throwing them on the field indiscriminately. Meanwhile, these same farmers agree such practice can damage or be hazardous to the environment (Nnamonu and Ali, 2013; CFSPH, 2010)

Table 1. Mode of Container Disposal Compared to Production Systems.

	Production System			
	Organic	**Inorganic**	**Organic and Inorganic**	**TOTAL**
Burn/Incinerate	0	26 (33.8)	11 (50)	37 (32.7)
Pit burial	0	31 (40.3)	9 (40.9)	40 (35.4)
Indiscriminate	0	20 (26.0)	12 (9.1)	22 (19.5)
Bio-degradable	14 (100)	0	0	14 (12.4)
	10 (100)	77 (100)	22 (100)	113 (100)

Source: Field Survey, 2017

Table 2. Mode of Container Disposal and Categories of Production Systems.

	Categories of Organic & Inorganic Chemical Applied						
	Inorganic fertilizers only	**Pesticides only**	**Inorganic fertilizer & pesticides only**	**Organic fertilizer only**	**Bio-pesticides and Organic fertilizer**	**Mixed method**	**TOTAL**
Burn/Incinerate	3 (75.0)	0		0	0	11 (50.0)	37 (32.7)
Pit burial	1 (25.0)	0	31 (43.1)	0	0	8 (36.4)	40 (35.4)
Indiscriminate	0	1 (100)	18 (25.0)	0	0	3 (13.6)	22 (19.5)
Bio-degradable	0	0	0	1 (100)	13 (100)	0	14 (12.4)
	4 (100)	1 (100)	72 (100)	1 (100)	13 (100)	22 (100)	113 (100)

Source: Field Survey, 2017

Table 3. Mode of Container Disposal Compared to Production Specification.

	Production Specification		
	Greenhouse	**Open field**	**TOTAL**
Burn/Incinerate	5 (50.0)	32 (31.1)	37 (32.7)
Pit burial	5 (50.0)	35 (34.0)	40 (35.4)
Indiscriminate	0	22 (21.4)	22 (19.5)
Bio-degradable	0	14 (13.6)	14 (12.4)
	10 (100)	103 (100)	113 (100)

Source: Field Survey, 2017

3.3.2 Application around Water Body

The analysis revealed that out of the total 113 respondents, 42.51% representing 49 respondents were conscious not to apply Agrochemicals in and around water bodies within or external to their farmlands. On the other hand, 30.09% representing 34 of the respondents admitted that they apply agrochemical around water bodies, implying the probability of negligence. However, about 27.40% representing 30 of the respondents did emphatically indicate that they do keep distance between areas of their farmlands where the crops were due to chemical treatment against pests and diseases. This could be attributed to environmental education. Some of the respondents might benefit from previously. Studies have confirmed, in most cases, water bodies accumulate nutrients from upstream farming activities (Habib *et al.,* 2017). As a result, measures must be taken to protect waterways, wetlands, and drinking water sources when spraying Agrochemicals (PERSUAP, 2013).

3.4 Agrochemical Use, Crop Production and Farm Sizes

The use of Agrochemicals (fertilizer and Pesticide) as a means of increasing food production is significant (Ngowi, 2003; Fianko *et al.*, 2011) for the food security agenda. Pesticides uses have numerous beneficial effects, including crop protection and preservation of food. WHO (2008) categorized pesticides use as: (1) Insecticides (e.g., organochlorines, organophosphates, and carbamates) (2) Herbicides or weedkillers (e.g., paraquat, glyphosate, and propanil). (3) Fungicides (to kill mould or fungi). (4) Rodenticides (to kill mice, rats, moles, and other rodents). Alternatively, Integrated Pest Management (IPM) strategies, tree nutrient fixers, and animal manure as fertilizers are novel and self-created proven to work well for adapted local conditions (PERSUAP, 2013). From the study, Inorganic fertilizer and pesticides were found to the overarching type (63.72%) of crop production, and an appreciable quantity of Bio-pesticides and organic fertilizer (11.50%) was used for organic farming as shown in Fig. 6.

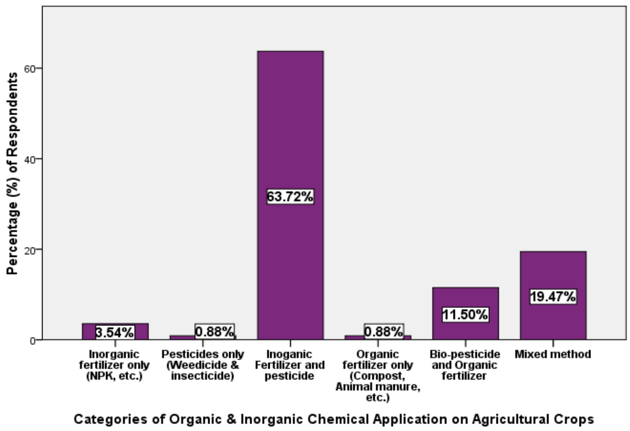

Figure 6. Agrochemical Use on Crops.

Farm sizes were analyzed to determine the category of Agricultural crops in general with the highest land-area under cultivation. The study established that farmers (respondents) who cultivated both Food and Cash crops cultivated the highest land-area (same piece of land), with about 78% of them having between 16-20 acres and 50% with 21- more acres as shown in Fig. 7. Compared to cash crops only, the greater shares of the farmlands were between 11-16 and 21-more acres, respectively, for 50% of respondents in that group. More so, the vegetable-only production was largely cultivated on between 1-5 acres of land area. It is not surprising that vegetable production was farmed on smaller land–areas because it is heavily characterized as labor and time-dependent activity with an enormous irrigation requirement.

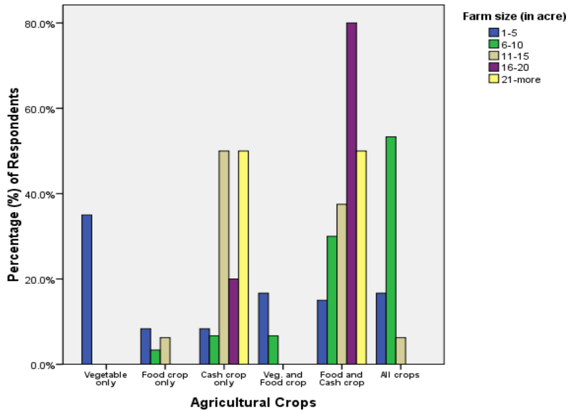

Figure 7. Relationship between Agricultural crops and Farm sizes

Relative to the production (organic and inorganic) system, 59% to 98% of respondents under inorganic systems typically applied most Agrochemicals on farmland across all the farm size categorization, ranging within 1-21more acres highlighting the intense and massive dependence of agrochemical use for crop production as shown in Fig. 8. In contrast, organic production revealed the least of farm sizes. This could also be attributed to the fact that yield performance could be generally low when the schemes are not managed appropriately, sometimes accounting inadequate technical know-how on home-made bio-pesticide and compost preparation on the part of respondents.

It is acknowledged that organic food products enjoy premium as the safest and devoid of several consequences on health and the environment. According to literature, the goal of organic farming is to minimize the risk to human and animal health and natural resources (Treadwell *et al.*, 2010)

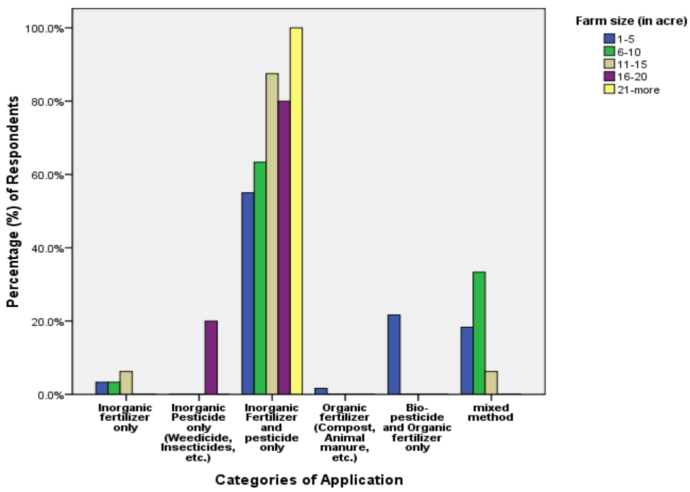

Figure 8. Categories of Agrichemical and Farm Sizes

Relationship assessment between Agrochemicals application and crop produced from all the study sites by the smallholder farmers revealed that Inorganic fertilizer and Pesticide use recorded the highest percentages regarding various crops under the study's consideration. About 85% of respondents who cultivated Cash crops such as Cocoa and Rubber profoundly relied on the use of Inorganic fertilizers and Pesticides, whiles 83% and 58% respectively in the same category of Inorganic fertilizer and Pesticide users cultivated vegetables, and Food and Cash crops combinations as shown in Fig. 9. Nonetheless, the use of Bio-pesticides and Organic fertilizers, as well as the mixed approach in Agrochemical users on the parts of the respondents, was notably significant in terms of application on the farm. This implies that cash crops such as cocoa, rubber, oil palm are intensively managed with Agrochemical chiefly concerning insect, disease, and weed control, soil nutrient enrichment, etc. Hence, as the practices of a substantial number of Agrochemicals are applied, farmers need to be cautious in handling and application as there could be resulting consequences regarding the environment, public health, and safety. A report from PERSUAP (2013) mentioned that most pesticide poisonings result from careless handling practices or from a lack of knowledge regarding the safe handling of pesticides.

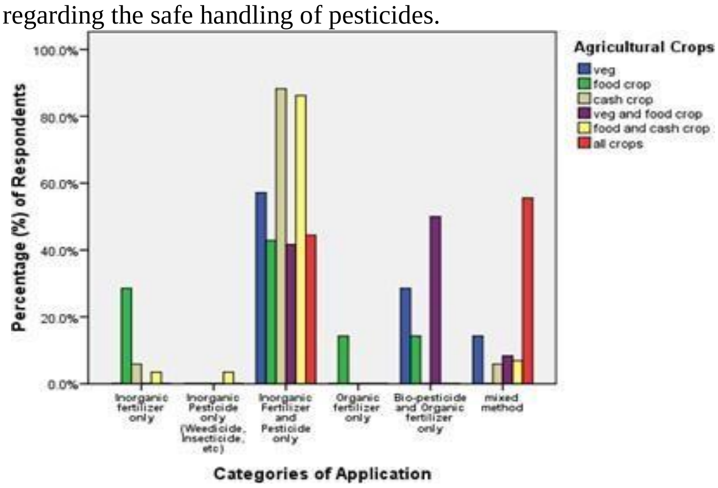

Figure 9. Categories of Agrichemical and Agricultural Crops

4.0 Conclusion

The study revealed that crop production was predominantly Pesticide and Inorganic fertilizer based. This was mainly because cash crop production was the overarching livelihood depended on by the respondents, and thus, control against pest and disease are central to yield and profitability. The study could deduce from the results that the massive application of the Agrochemicals was a result of the insurgence of pest (insect and weeds) and desire to improved the performance of crop in yield. However, associated implications/risks need to be taken seriously, particularly related to users' health. According to Afari-Sefa *et al*. (2015) and Mabe *et al*. (2017), sensitization and educational programs for farmers through interactive platforms such as radio discussion could be helpful to make farmers well-formed in their day-to-day dealing with Agrochemicals. Also, certification programs for farmer would enhance the development of safe-handling practices, storage and waste disposal strategies for farmers. An example of such a program could the Common Agricultural Policy (CAP) in Europe which ensures sustainable on-farm practices including prevention against water pollution (Heinz, 2008; Volk *et al*., 2009). Although the massive reliance on Agrochemicals revealed in many of the production regimes, Bio-pesticides, and organic fertilizers (manure, compost, etc.) use were noted to be used marginally by the respondents. Safety measures acknowledged by some of the respondents in the use of agrochemicals could be accorded with much precautionary practices previous formal or informal pieces of training they had benefited from. Nonetheless, a considerable percentage of respondents request to receive training on the judicious and safe use of Agrochemicals. The study recommends that stakeholders from both Government and Non-governmental agencies actively take role play in the awareness creation and regulations regarding safe-use and application of Agrochemicals to avoid noticeable residual levels in crops eventually. Especially as there is a high tendency to transmission through the food chain and eventually become a health concern.

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