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Full Length Research Paper

Determinants of farmers' pesticide usage patterns in tomato production in Ghana. A case study of Akomadan

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Application of agrochemicals by farmers has become one of the most effective measures to pest infestation and as weed control mechanism, aimed at productivity improvement and increased farm level profits. In Ghana, though scanty, empirical evidence points to overuse of agrochemicals in vegetable production. This paper sought to analyze the extent and factors that influence misuse of pesticides in tomato production in Akomadan. Random sample of 120 tomato farmers was used for the study. The study revealed a wide variation in the levels of pesticides usage among farmers. More than half (62%) of the farmers overused pesticides. Again 76% of the farmers did not follow dosage recommendation on labels. Using logistic regression model, the study revealed that factors such as the use of non-hybrid variety of tomato, age, education, farm size, farming experience, source of seed, farming system practiced and other economic activities of the farmer explained farmers' pesticides over application patterns. We recommend that environmental protection agency and its allied institutions responsible for agrochemical regulation should intensify education on and monitoring of pesticides application among farmers to avoid possible table food poisoning, protect public health and environment and to avoid insect pests resistance to pesticides.

Keywords: Ghana, misuse, pesticides, tomatoes, logit analysis.

INTRODUCTION

Enhancing food production in a sustainable environment to ensure food availability, safety and to promote public health under the current global call for attention and action on climate change, presents a major challenge to developing countries on their food security agenda. Ghana like many developing countries is faced with increasing human population growth, resource scarcity and depletion of soil fertility and the resultant decreasing yields. To ensure that agricultural commodities are produced efficiently, crop and animal production systems are intensively managed. More importantly, sustainable agricultural production aimed at improved productivity and higher farm level financial returns is characterized, among others, by extensive application of pesticides and chemical fertilizers. Growing concerns have however been raised with respect to misappropriate use of pesticides particularly in vegetable farms. While the magnitude of impact varies, pesticides application has tremendous harmful effects on water bodies and their aquatic animals (Fianko et al., 2011). It also has serious public health implications as these chemical residues can lead to reduction in immune responses, increase the risk of infertility and sterility and cancer (Park et al., 2019; Shrestha et al., 2019; Ntow, 2008). It has been estimated

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that below 0.1% of synthetic pesticides applied for controlling pests reach the targeted pests with the remaining 99.9% reaching the environment (Pimentel, 1995).

In Ghana, agro-chemicals are extensively used, particularly, in vegetable production. The total utilization of pesticides and other agrochemical products in the production of vegetables have risen considerably over the past decade in response to rising demand for and resultant increasing supply of vegetables. Available figures indicate that pesticides imports rose from 13,035 tons in 2005 to 339,507 tons in 2015 (EPA, PPRSD/MoFA, 2015 cited in Diarra and Tasie, 2017).

As noted above, while usage of pesticides and other agrochemicals enhance productivity of agricultural produce and vegetables in particular, consumer and public health implications of chemicals misapplication are of great concern to individuals and the government as well. These concerns for agrochemical misuse in vegetable farming particularly continue to receive much more attention. For instance, in 2017 experts warned of the increasing danger associated with misuse of pesticides in vegetable farming in Ghana (Joynews, 2017). While extensive research has been conducted in agrochemical usage in Ghana and other countries, most of the studies have focused on assessing different agrochemical products sold to farmers, the extent to which farmers use them on their crops or assessing farmers choices' for particular agrochemical (see Fianko, et al., 2011; Laary, 2012; Wandaat and Kugbe, 2017; Sharifzadeh et al., 2018). Very few studies (Kwakye et al., 2018; Wandaat and Kugbe, 2015; Mariyono, 2008; Selvarajah and Thiruchelvam, 2007; Carlson and Wetzstein, 1993) have attempted to establish association between knowledge, choices and protective practices of pesticides and farmers' socio-economic characteristics and or production practices. Studies that profile pesticides users based on their pesticide usage intensity or misuse and that comprehensively identify factors that explain their practices are very limited. Thus, the need to better understand the current pesticides usage and management practices of vegetable farmers is of investment, food safety and agricultural extension policy importance. This study in effect sought to assess farmers' pesticides usage patterns and to ascertain the factors that explain pesticides usage intensity among tomato farmers in Akomadan using logit analysis. Understanding the intensity of pesticides application and the determinants of pesticide overuse is important to directing policy recommendation, monitoring and targeting towards reducing pesticide over usage among farmers to avoid possible unintentional table food poisoning, protect public health and the environment.

RELATED LITERATURE

Synthetic agrochemicals usage have become an essential constituent of agriculture production systems around the world due to changes in climatic elements, degradation of soil composition and the need to produce vegetables and agricultural crops intensively to meet the demand of the growing population. Thus, complete elimination of synthetic chemical pesticides use without appropriate substitution of alternatives in intensive farming can substantially reduce vegetable crop yields (Knutson, 1999); and in many cases, can even lead to zero levels of vegetable production. The damage attributed to pests and diseases infestation varies by geological location, nature and system of farming and history of pest infestation among others and as a result lead to varying intensity of pesticide usage, given farmers' socio-economic characteristics. From economic perspective, the decision to use pesticides is related to price of pesticides, expected crop prices at the time of harvest (ex-ante price), price of other agricultural inputs, and farmers' expected net returns from selling the produce (Sharifzadeh et al., (2018); Carlson and Wetzstein, 1993). In this respect the level and intensity of pesticide usage are relatively higher for high value crops grown for market (such as vegetables and fruits) than crops grown for home consumption (such as cereals and other staples). In Bangladesh, Rahman (2003) revealed that some rice farmers treated pesticides as a substitute for fertilizers; they increased pesticide usage on rice production as fertilizer prices increased. Mariyono (2008) also reported that an increased prices of rice and soybean in Indonesia induced farmers to use more pesticides to get more farm income and profit. An increase in the price of pesticide is expected to reduce its demand. A study conducted in Sri Lanka by Selvarajah and Thiruchelvam (2007) reported that high prices for pesticides led to a reduction in the level of pesticides used by farmers; however, households with more family members (available labor for spraying) used more pesticides. Conceptually, farmers' decision to use pesticides can be equated to purchasing insurance.

Moreover, farmers' decision to use pesticides at a given frequency and level of intensity is also influenced by their past experience with pest infestations, crop types, some level of expectation as per the crop condition at the moment and expected return from the produce or expected crop productivity (Carlson and Wetzstein, 1993). A study conducted in USA by Heimlich et al. (2000) revealed that a substantial reduction in herbicide usage is associated with increased adoption of genetically modified seeds of agricultural crops.

In their analysis of rural-urban pesticides misuse in Tano South district of Ghana, Wandaat and Kugbe (2015) found significant interaction between method of pesticide application and farm size. Sharifzadeh et al., (2018) assessed Iranian rice farmers' criteria for pesticide selection and usage in the pest control process using factor analysis and concluded that performance and effectiveness criteria had the highest importance for farmers when selecting and using pesticides, followed by financial and accessibility criteria.

Focusing on farmers' protective behaviours, Afshari et al. (2019) found that farmers in developing countries use

harmful pesticides while taking few or no protective measures. In a descriptive study conducted in Twiserkan County in western Iran among 474 farmers from 104 villages, they indicated that among the assessed factors, only physiological arousal and habit were found to have a significant and positive effect on the use of personal protective equipment, but the intention and contextual factors had no significant relation with the use of personal protective equipment. Kwakye et al. (2018) found significant association between educational level attained and knowledge; work experience or duration of farming was also found to correlate with knowledge of respondents, attitude and farm management practices. Their results indicated that farmers substantially used overdose levels of thirty seven pesticides across their study fields when compared to the recommended dose. The literature on pesticides usage and related health and environmental implications is extensive. Limited empirical studies have rigorously and comprehensively assessed socio-economic, institutional and agro-food policy factors that do explain farmers' pesticides usage intensity levels.

MATERIALS AND METHODS

The survey was conducted on 120 randomly selected tomato farmers in Akomadan tomato production area of the Ashanti region of Ghana. A questionnaire containing open and close ended questions was designed to obtain the data through interviews with farmers. The questionnaire covered farmers' perception on pesticide management practices, knowledge on and pattern of pesticides application. Socio-economic characteristics and farming practices of the farmers were also covered.

Empirical model

In addressing the major research objective, that is, assessing pesticides usage patterns and to ascertain the factors that explain the patterns among farmers in the study area, two levels of pesticides applications were defined. Thus farmers were grouped into two categories based on how appropriately they apply pesticides (insecticides and fungicides) in terms of intensity by frequency of usage; appropriate pesticide user group were respondents who apply pesticides in response to pests infestation/threat and maximum of four in a normal production season (long dry season) as a preventive measure. Excessive/misuse of pesticide group represents respondents who on average apply pesticides above four times in a normal production season as preventive measure or indiscriminately. In this respect our dependent variable is defined as binary variable. Factors that explain appropriate usage of pesticides may in addition to socio-demographic features include previous farmer experience with and knowledge of pest infestation, farming experience, education, source of pesticides usage information and farm characteristics (see Table 2.0).

Following the general modelling framework of consumer preference and binary choice models, farmers' levels of pesticides misuse can be stated as decision makers' choices between alternatives courses of actions or options over which choices are made (Train, 2009). With this characterisation, the discrete choice problem can be derived and explained following the modelling framework developed by (Luce, 1959; McFadden, 1974; Train et al., 1987; Ben-Akiva et al*.,* 1993) and other extensions as cited in Abunyuwah & Awuah (2014).

Given our binary choice problem, a logit representation is adopted for the analysis. Thus, whether a farmer does (OP =1) or does not overuse pesticides (AP =0) given observable individual characteristics (*X*) and unobserved random component (ε); if the errors are assumed iid extreme value, then the binary logit model as stated in equation (1) below obtains. The probability that a farmer will exhibit an action P_i *(OP)* is given by:

$$P_i = \text{Prob}(OP = Z = 1) = \frac{e^{Z_i}}{e^{Z_i} + e^{Z_j}}$$

where, $Z_j = \beta^{'} X_j \quad or \quad (\beta_o + \beta_1 X_{1j} + ...\beta_k X_{kj})$ represents the *representative variable or* an unobserved latent variable which is usually specified to be linear in parameters; vector X_j consists of observed *k* variables relating to alternative *j*. Specification (1) can be written as equations (2) and (3) below, for actions *i* and *j* respectively, by dividing the numerator and denominator of equation (1) by the numerator:

$$P_i = \text{Prob}(OP = Z = 1) = \frac{1}{1 + e^{(Z_j - Z_i)}}$$

$$P_j = \text{Prob}(AP = Z = 0) = \frac{1}{1 + e^{(Z_i - Z_j)}}$$

If parameters for variables in *Z* relating to action *j* are normalised to zero as in our data set and in most binary logit applications, then equations in (2) and (3) above reduce to popular binary logit forms as stated in specifications (4) and (5) respectively below (see Abunyuwah and Awuah, 2014).

$$P_i = \text{Prob}(OP = Z = 1) = \frac{1}{1 + e^{(-Z_i)}}$$

$$P_j = \text{Prob}(AP = Z = 0) = \frac{1}{1+e^{(Z_i)}} \quad (5)$$

Based on the above model, our dependent variable which is ordered, but binary was explained by farmer socio-economic, demographic, experience, educational, and farm characteristics (see Table 2.0).

RESULTS AND DISCUSSIONS

Table 1.0 presents the demographic characteristics of the 120 respondents sampled from the study area. The average age of respondents was 38.44 years, 78 (65.0%) of the respondents were male and 42 (35.0%) farmers were females with an average household size of 6. On the average, each farmer had worked on a farm for at least 15 years and applied pesticides themselves on their own farms. The average land size was 2.87 acres with the majority (92.5%) of the farmers owning between 1 and 5 acres of plot.

Pesticide usage pattern and management

The farmers have adopted an array of pesticides usage pattern in the study area. The agrochemicals used by the farmers comprised of insecticides, fungicides and herbicides. All the respondents applied pesticides intensively, especially herbicides. The high usage of herbicides was as a result of its effectiveness and ease of clearing weeds as compared to solely relying on the conventional methods of weeding using simple farm tools. Similar results were found by Ntow et al. (2006) and Kwakye et al. (2018). The usage pattern of pesticides also varied among farmers. On frequency of pesticides application, the survey revealed that more than half of the farmers (62%) applied pesticides (herbicides and fungicides) in a normal production season beyond four (4) times as a preventive measure .The other 38% represents farmers who do not on average exceed a maximum frequency of four as preventive measure for a normal production season. On their major reason for frequency of pesticides application, about 44% of the later group (16.7% of the respondents) indicated that they apply pesticides whenever they detect pest infestation threat on their crops only; and the rest 56% (21.3%) apply pesticides as precautionary and curative measure based on symptomatic observation of pest and insect or disease infestation. On dosage determination of pesticides application, only about a quarter (24.17) of the farmers followed recommended dose on labels, while the rest determined the concentration by observing the changes in colour, smell and falling on “experience” and other crude methods. This observation supports the findings of Kwakye et al. (2018) who reported high level of pesticides overdose across their study fields.

The survey also revealed that only fifteen (15) respondents (12.5%) used all basic required protective gears (boots, coats, gloves, masks); in all 89 (74.2%) respondents used farm boots, 17(14.2%) used protective clothes/long coats, 16 (13.3%) used gloves and mouth/nose guards, while 28 (23.3%) did not use any of these protective gears. These observations differ from Kwakye et al. (2018), who observed that only 16% of their respondents wore boots but none used gloves, goggles or other protective gears. All their respondents however stated that they practiced care and sprayed at appropriate hours of the day (e.g. morning). These findings support a study conducted by Fianko et al. (2011) which reported that of the 1,215 cases of toxicological examination of vegetable farmers, 963 tested positive for chemical poisoning with 30% of chemical poisoning directly related to the misuse of pesticides and its mismanagement.

Determinants of pesticides usage intensity among the farmers

In explaining the farmers’ stated levels of pesticides usage pattern (intensity by frequency), the binary logit analysis was performed as expressed in equations (1) to (5) above to examine and explain the factors that influence the levels of pesticide misusage. The results from the analysis are reported in Table 2.0 below. The model reasonably fitted the data, judging from the likelihood ratio test and AIC test produced from the Stata output.

Based on the results from the estimated model, we can infer that over-usage/misapplication of pesticides decreases with farmers’ age. This could be due to learning effect and or the fact that older farmers often lack the adequate strength required in the application of pesticides. Younger farmers have the passion for acquiring higher yields per unit area, and with the notion that frequent application of pesticides increases yields, this result is not unexpected. In Ntow et al. (2006), it was reported that younger farmers (below 45 years of age) sprayed more pesticides than older farmers (above 45 years of age) and were the most vulnerable group to poisoning symptoms. Kwakye et al. (2018) also recorded significant association between age and knowledge variables; and age and practices but did not provide direction of association.

As expected, variables for years of tomato farming experience and levels of education have negative impact on the level of pesticide over-usage/misapplication. Thus, misapplication or over-usage of pesticides increases among farmers without any level of formal education and farmers with basic level of education. These results

Table 1.0. Socio-Economic Characteristics of the Farmers.

VARIABLE	MEAN / PERCENTAGE (%)
Age of Respondents	38.44
Sex	
Male	65%
Female	35%
Year of Farming	15.033
Household Size	6.55
Acreage of Land	2.875

Table 2.0. Factors explaining pesticides usage intensity.

Variables	**Estimates**	**Standard Error**	**Significance Level**	**Odd Ratio**
SEX	0.288	0.041	0.0087***	1.334
AGE	-0.11	0.012	0.0027***	0.895
FEXP	-0.800	0.04	0.0001***	0.449
HUSZ	0.26	0.036	0.007***	1.296
FRMZ	1.083	0.381	0.004***	2.954
Education				
No Formal Education	0.178	0.0148	0.0005***	1.1948
Basic education	0.200	0.0400	0.0251**	1.2214
Secondary	-0.220	0.7680	0.5927	1.2460
Higher	RC			
Other Economic Activities				
Civil Servant	-0.353	0.730	0.4868	0.7025
Artisanship	0.334	0.035	0.0021**	1.3965
Trading	-0.217	0.051	0.0380**	0.8049
Other Crop Farming	0.343	0.093	0.0544	1.4092
Only Tomato Farming	RC			
Type of Farming System Practiced				
Continuous Farming	0.991	0.25	0.048**	2.6940
Crop Rotation	-0.659	1.037	0.5250	0.5170
Shifting Cultivation	RC			
Source of Seedlings				
Own / Friends	1.108	0.559	0.0101***	3.0280
Agrochemicals shops	RC			
Type of Tomato Variety				
Akoma	0.447	0.049	0.0027***	1.5640
Pertofake & Power	RC			

Source: Authors estimation from Stata.

collaborate with Giri et al. (2014) who reported that writing and reading ability of farmers played an important role in pesticides usage in Nepal. Farmers with no education and basic education are 1.1948 and 1.2214 more likely to overuse pesticides respectively than those with any higher level of education. Education and tomato cultivation experience enable farmers to better predict symptoms, nature and type of damages likely to be caused

by the pest attacks. Education and experience might also improve understanding of pest biology, and effectiveness of pesticides on the pest, and also its consequences to the local environment.

Farm size has positive influence on the level of pesticides usage. As expected farmers who operate on a larger scale tend to be more concerned about pest attack and their investments and in effect are likely to apply pesticides more intensively. This finding is in agreement with Rahman (2003), who reported that larger farms in Bangladesh (and with more crop acreage) used higher levels of pesticides on vegetables (per unit of land) than smaller farms. Household size was found to influence the frequency of application of pesticides. Households with more family members serve as labour for spraying and other farm activities. This result supports a study conducted by Selvarajah and Thiruchelvam (2007) in Sri-Linka. The variety of tomato grown and source of seed have positive effects on level of pesticide usage. Many farmers in the study area grow non-hybrid varieties. The results suggest that farmers who grow local (Akoma) variety of tomato are more likely (about 3.028 times) to overuse pesticides than those who grow hybrids. This suggests that local tomato types are more susceptible to pests and diseases infestation. This result is in support of a study by Mariyono and Bhattarai (2009) who reported that farmers who used non-hybrid varieties of Chili applied higher level of pesticides in Indonesia.

The results of the study also revealed that sex influenced the level of application of pesticides. The estimates indicate that female farmers are more likely (about 1.3337 times) to over apply pesticides than their male counterparts. In this study, it was found that higher usage of pesticides increases among farmers who engaged in other economic activities. Farmers who produced other crops or engaged in artisanal businesses are 1.3965 and 1.4092 times likely to over apply pesticides respectively. The type of farming system practiced by the farmer also influenced the level of pesticides usage in the study. As expected, farmers practicing continuous cropping used higher level of pesticides in the study area.

CONCLUSION

The findings from the study indicated that most of the farmers use higher levels of pesticides on a regular basis in their farming activities.. Tomato farming in the study area is a male dominant activity with the men making up 65% of the respondents sampled but females are likely to use higher level of pesticides than males. Farm size, level of education, other economic activities, the type of seed and age of farmers significantly influenced usage of pesticides in the study area. It is recommended that environmental protection agency and its relevant institutions responsible for agrochemical regulation intensify education on and monitoring of pesticides application among farmers to avoid possible table food poisoning, protect public health and environment and to avoid insect pests resistance to pesticides.

REFERENCE

Abunyuwah I, Awuah RT (2014). Concerns about unwholesome packaged food in Ghana: the case of Mampong municipality. Int. J. Food Safety, Nutr. Public Health 5(1) pp. 7-15

Afshari M, Poorolajal J, Rezapur-Shahkolai F, Javad-Assari M, Karimi-Shahanjarini A (2019). Which factors influence farmers' use of protective measures during pesticides exposure?. Workplace. Health & Safety. 216507991982704. 10.1177/2165079919827042.

Carlson GA., Wetzstein M E (1993). Pesticides and pest management. In: Carlson GA., Zilberman D, Miranowski JA (Eds.), Agricultural and Environmental Resource Economics. New York: Oxford University Press.

Diarra A, Tasie O (2017). National Implementation of Regional Pesticide Policies in West Africa: Ghana Case Study Report. Michigan: MSU.

Fianko JR, Donkor A, Lowor ST, Yeboah PO (2011). Agrochemicals and the Ghanaian environment, a review. J. Envt. Prot. Vol. 2. Pp 221-230.

Giri YP, Thapa RB, Shrestha SM, Pradhan SB, Maharjan R, Sporleder M, Kroschel J (2014). Pesticide use pattern and awareness of pesticides users with special reference to potato growers in Nepal. Int. J. Devt. Res. Vol. 4(11). Pp. 2297-2302.

Greene WH (2003). Econometric Analysis. Prentice Hall, New Jersey.

Heimlich RE, Fernandez-Cornejo J, McBride W (2000). Genetically engineered crops: Has adoption reduced pesticide use? Agr. Outlook, Econ. Res. Service, USDA.

Knutson RD. (199). Economic impacts of reduced pesticide use in the United States: Measurement of costs and benefits. AFPC Policy Issues Paper 99-2.

Kwakye MO, Mengistie B, Ofosu−Anim J, Tetteh A, Nuer K, Van den Brink PJ (2018). Pesticide registration, distribution and use practices in Ghana. J. Environ Dev Sustain. https://doi.org/10.1007/s10668-018-0154-7

Laary JK (2012). Dry-season farming and agrochemical misuse in Upper East Region of Ghana: Implication and way forward. J. Agr. Food & Envt Sci. 5. 1-10.

Mariyono J (2008). The impact of integrated pest management technology on insecticide use in soybean farming in Java, Indonesia: two models of demand for insecticides. As. J. Agr. Devt. Vol 5. Pp 43-56.

Mariyono J, Bhattarai M (2009). Factors determinant of pesticides use in chili pepper farming in Central Java, Indonesia. J. Agr. Syst. Online. *https://www.aciar.gov.au/file/76121/download?token=t3ch8peT*. Accessed Jan. 5, 2019.

Ntow WJ, Gijzen HJ, Kelderman P, Drechsel P (2006). Farmer perceptions and pesticide use practices in vegetable production in Ghana. J. Pst. Mgt. Sci. Vol. 62(4). Pp 356–365.

Ntow, W. J. (2008). The use and fate of pesticides in vegetable-based agro ecosystems in Ghana. Phd Theses Submitted to Wageningen University. Netherlands.

Pimentel D (1995). Amount of pesticides reaching target pest: environmental impact and ethics. J. Agr. Envt. Eths. Vol. 8(1). Pp17 - 29

Rahman, S. (2003). Farm-level pesticide use in Bangladesh: Determinants and awareness. Agr. Ecos. Envt. Vol. 95. Pp 241–252.

Selvarajah A, Thiruchelvam S (2007). Factors affecting pesticide use by farmers in Vavuniya district. Trop. Agr. Resh. Vol.19. Pp 380–388.

Sharifzadeh MS, Abdollahzadeh G, Damalas CA, Rezaei R (2018). Farmers' criteria for pesticide selection and use in the pest control process. Agriculture, 8, 24

Train K (2009). Discrete choice methods with simulation. 2nd Ed. New York: Cambridge University Press.

Wandaat EY, Kugbe JX (2015). Pesticide misuse in rural-urban agriculture: A case study of vegetable production in Tano South of Ghana. As. J. Agr. & Food Sci, 3.