

Agricultural Pesticides used by small-scale farmers in Kenya: What are the experiences of the farmers?

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Research Article

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Abstract

Introduction: Several crops are grown in Kenya for commercial and subsistence purposes. However, pests have become a major threat to farming. To address this, farmers use different kinds of pesticides. While it is a fact that pesticides are heavily used, there is scanty literature on the nature and types of pesticides used by small scale farmers in Kenya. Further, the extent to which the integrated pest management plan is used is not known. Therefore, this survey sought to explore major crops grown in Kenya, pests affecting them, nature of agricultural pesticides used, and finally, the effectiveness of the agricultural pest control methods used by small scale farmers.

Methods: This was a descriptive study. 95 respondents from different counties in Kenya participated in this study. A self-administered questionnaire which comprised of open-ended and close-ended questions were used in data collection.

Findings: The studies revealed that farmers practiced subsistence farming. Major pests affecting crops were insects and rodents. Pests majorly affected crops while they were on the farm. Most of the agricultural pesticides used by the respondents were insecticides and rodenticides. The study established that artificial pesticides are more effective and most preferred than home-made pesticides.

Recommendations: The study recommends the adoption of integrated pest management, organic farming, and communal approaches to pest control. It further recommends training on best practices of agriculture.

Introduction

Agriculture is the backbone of the economic growth in Kenya. According to USAID, about 75% of Kenyans earn all or part of their income from this sector(USAID - Kenya, 2019). Agriculture accounts for 33% of the nation's Gross Domestic Product (GDP) (USAID - Kenya, 2019). In Kenya several crops are grown such as beans, green grams, maize, vegetables, watermelon, tomatoes and fruits of different kinds. Crop damage caused by insects and pests and diseases is common in developing countries and creates a great economic loss(Loha, Lamoree, Weiss, & Boer, 2018). Pests have become a major threat to agriculture in Kenya. For instance, a report by WVI observed that in 2017 an estimated, 40 percent of farms were reported to be infested with the fall armyworm (World Vision International, 2017). To address this, farmers use different kinds of artificial pesticides and home-made pesticides. Pesticides have important benefits (International Food Information Council Foundation, 2019). They improve productivity, protection crop losses, control vector diseases and in some scenarios, pesticides increase quality of food [5] [6]. This supports the argument that without the use of pesticides, farmers would not be able to harvest significant yields (Soko)

A study by Lohaa found out that there were increases in imports of pesticides in Kenya from 2008 to 2015. It further found out that there were more than 11 companies in Kenya involved in the manufacturing of varying pesticide products(Loha, Lamoree, Weiss, & Boer, 2018). In a study on potential

environmental impacts of pesticides use in the vegetable sub-sector in Kenya, it was revealed that that organophosphates, carbamates, pyrethroids, tetranortriterpenoids and carcinogens were used (Macharia, Mithofer, & Waibel, 2009). The study further established that approximately 60% of the pesticides quantities were indicated to be bad actor chemicals, meaning they affected the environment negatively, 64% to be ground water contaminants, and 47% very harmful to beneficial insects (Macharia, Mithofer, & Waibel, 2009). (Soko, 2018). (Soko)

Literature on pesticides in Kenya is skewed towards pesticides and health. Several studies have documented pesticides and health (Macharia I., 2015). (Loha, Lamoree, Weiss, & Boer, 2018) pesticide and its effect on heavy metals on fish and aquatic organisms in Kenya (Nzeve, 2014). Only a few have focused on pesticide use, for example a report on pesticide use in Kenya (USAID Kenya Agricultural Value Chain Enterprises, 2014). Also, most of such studies focus on large scale farmers leaving gaps on pesticides use by small scale farmers in Kenya. Thus, this study sought to find out the following: crops which are mostly affected and by pests and the state at which they are affected, agricultural pests found in parts of Kenya, environmental conditions that encourage pests to thrive. In addition, the study sought to investigate which forms of pesticides, home-made or artificial forms, are mostly used and evaluate the level of effectiveness of agricultural pest control methods used. Finally, the study explored ways of improving the methods of pest control and assessed the changes observed in local environment regarding presence of trees, farming methods, existence of apiary activities.

Materials And Methods

Study site

This study involved farmers from different counties in Kenya. These included” Kajiado, Kakamega, Nyandarua, Lamu, Machakos, Nakuru, Muranga, Bungoma, Busia, Embu, Kericho, Kisumu, Makueni, Nairobi, Siyaya, Homabay, Kilifi, Meru, Nyeri, Taita Taveta, Uasin Gichu, Baringo, Kiambu, Kitui, Laikipia, Marsabit, Mombasa, Nandi, Narok, Transzoa and Vihiga. The respondents were selected because they were current or former students of Tangaza University College, Kenya, studying MBA in Social Entrepreneurship which runs courses on agri-business. The program is offered by University of Milan and was launched and operates at Tangaza University College in Kenya since 2014. The program is based on individualized consultancy through business coaching, application of business ideas to real life business, mentorship and creating networks. One of the key focus of program is agribusiness. In order to get the respondents, an online google-form questionnaire was sent to all the 257 current and alumni of the MBA program who were doing agribusiness. They were purposively selected because target population had knowledge of agribusiness.

Questionnaire survey

The respondents were the people who practiced farming at various scales. They comprised of those who had a farm, who were supporting farmers by providing inputs to famers and finally those that had basic knowledge in agribusiness. The research focused on 95 farmers who filled the questionnaires online representing a 36% response rate. They comprised of 76 (80%) who had a farm, 6 (6%) who were supporting farming activities by providing inputs and 13 (14%) who had basic knowledge in agribusiness. The self-administered questionnaire had four parts and comprised of open ended and close ended questions. The first part sought to solicit background information of respondents such as gender, age, area where respondents were carrying our agricultural activities, types of crops grown by farmers, extent famers practice farming and size of the land used for farming. Part two sought to find out the experience of farmers in areas such as the most common pests in their farms, state of crops the pests destroy, environmental conditions that encourage these pests to flourish, artificial pesticides and home-made pesticides used to control agricultural pests, agricultural pest control methods mostly used and their effectiveness. The third part was on environmental related activities in farms. Specifically, this explored the prevalence of trees, ground cover, and use of fertilizers, apiary activities, gullies and the existence of firewood in the area. Finally, the fourth part sought to find out the methods of improving pesticide use.

Table 1: Questionnaire relating to the background information, experiences and perceptions

Part1: Background information	
	Gender
	Age of respondents
	Area where the respondents were carrying out agricultural activities
	Type of crops grown by farmers
	Extent farmers practice farming/gardening, agriculture
	Size of land used for farming/gardening, agriculture
Part 2: Experiences of farmers	
	Most common pests in the respondents' farms
	Nature of food do these pests cause harm
	Environmental conditions that encourage pests
	Artificial pesticides used to control agricultural pests
	Home-made pesticides used to control agricultural pests
	Agricultural pest control methods mostly used in your garden/farm
	Effectiveness of agricultural pest control methods used in the location of your garden/farm
Part 3: Environmental related activities in the area	
	There is increase in trees
	There is evidence of increase in ground cover
	There is increase in use of fertilizers
	Apiary activities are on the increase
	There is increase in the gullies (trenches in the area)
	Firewood is getting scarce
Part 4: Improving the practice	
	Methods to improve on the pest control methods

Data analysis

Data was analyzed using descriptive statistics. We used frequencies to summarize data that was collected from close ended and open-ended questions. Open-ended questions data was summarized into themes then frequencies were drawn.

Results

Results

Demographic and socio-characteristics of the respondents

Size of farms and nature of farmers

The 95 participants who comprised of 57% were male and 38% were female were small scale farmers cultivating on pieces of land of various sizes ranging from one acre to five acres. This shows that majority of farm owners are male. This concurs with a report which states that customary law and practices, prohibit women from owning or inheriting land and other forms of property in Kenya (Hakijamii, GI-ESCR, FIDA, 2016). Women are often a crucial resource in agriculture and the rural economy across the developing world (SOFA Team and Cheryl Doss, 2011). Women account for nearly half of the world's smallholder farmers and produce 70% of Africa's food but less than 20% of land is owned by them (Abass, 2018). (Gaafar, 2014). This shows that while men own land those working of the land are mostly women. 25% were small scale farmers who cultivates on farm sizes of below one acre. This is significant in that it can indicate the choice of pesticides these farmers are likely to use.

Environment where the farms were located.

To find out whether the location and nature of environment had any relationship with pest occurrences, we studied the vegetation cover and farming practices carried out by respondents. Regarding presence of vegetative cover, 60% of the respondents stated that there was increase of trees and 50% observed that there was increase in ground cover in the areas where their farms were situated. This implies that farms were moderately in the regions where there was vegetative cover. As for use of fertilizers, 84% witnessed increase in use of fertilizers. Farmers relied hugely on fertilizers implying that the soil nutrients were poor in the area. This could have been as a result of continual use of land with similar crops. Quite a small percentage 17% of the respondents experienced increase in apiary activities. This implies that the area is not conducive for the bees perhaps because of the farming practices in the area. The increase of trenches and gullies as observed by 39% of the respondents point to the poor methods of farming the area. The phenomenon of scare of firewood as observed by 88% of the respondents imply that there is a growing deforestation in the areas.

Table 2

State extent you agree with the statements	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree	
There is increase in trees	20%	40%	11%	24%	5%	100%
There is evidence of increase in ground cover	14%	36%	23%	23%	4%	100%
There is increase in use of fertilizers	45%	39%	8%	5%	2%	100%
Apiary activities are on the increase	3%	14%	40%	31%	13%	100%
There is increase in the gullies (trenches in the area)	13%	26%	28%	30%	2%	100%
Firewood is getting scarce	48%	40%	6%	4%	2%	100%

Crops that were mostly grown by the respondents

Table 3, presents the crops commonly grown by the respondents and crops most affected by pests. As indicated in the table 95% of the respondents grew vegetables 69% maize, 52% beans, 36% fruits, 25% Irish potatoes, 21% sweet potatoes, coffee 10 %, green grams 8%, Groundnuts 6%, Tea 5%, Wheat 4% and animal feed (grass) 2%. Cassava, sunflower, oats, pyrethrum, miiji and mira at 1% each. This shows that small-scale farmers concentrate on growing staple food crops than cash crops.

The most common crops affected by pesticides reported by the respondents were vegetables 98%, maize 59%, beans 32%, fruits 27%, Irish potatoes 17%, sweet potatoes 9%, coffee 8%, green grams 4%, Groundnuts 2% and Tea 2%. Interestingly, the crops mostly cultivated by farmers were the most affected by the pesticides. The study also revealed that food crops were most affected than the cash crops.

Table 3: Crops most grown and crops most affected by pests in Kenya

Type of crop Vegetables types and tomatoes	Crops most grown in the area where participants were practicing agriculture in Kenya		Crops most affected by pests in Kenya	
	Frequency	Percentage	Frequency	Percentage
	91	95%	94	98%
Maize	66	69%	57	59%
Beans	50	52%	31	32%
Fruits	35	36%	26	27%
Irish potatoes	24	25%	16	17%
Sweet potatoes	20	21%	9	9%
Coffee	10	10%	8	8%
Green grams	8	8%	4	4%
Groundnuts	6	6%	2	2%
Tea	5	5%	2	2%
Wheat	4	4%	3	3%
Grass	2	2%		0%
Cassava	1	1%	1	1%
Sunflower	1	1%		0%
Oats	1	1%	1	1%
Pyrethrum	1	1%		0%
Mijji	1	1%		0%
Miraa	1	1%		0%

Nature of crops affected by pests

Regarding the nature of crops, mostly affected by pests as reflected in Table 4, most of the respondents 66% stated that pests affected fresh foods, thus when the crops are in the farm, 26% stated that pests affected both fresh crops, packaged food, 7% stated that pests affected packaged food. This shows that the pests majorly affected crops while they were in the farm.

Table 4: Nature of food infested by pests (N=95)

Nature of crops affected	Frequency	Percentage
Fresh foods	57	66%
Packaged food	6	7%
Both fresh food, packaged	23	26%

Common Pests affecting crops grown in Kenya

Table 5 presents the common pests affecting crops in Kenya. As noted from the table 84% of the most common pests were caterpillar related pests. These were stalk borers, white flies, worms, army worms and cut worms. 44% were rodents, 31% were aphids, 26% termites and ants, 25% weevils, 23% fungus and

bright, 16% insects, and 9% were viral related pests. This indicates that the major pests affecting farmers were caterpillars, rodents aphids, termites, weevils and insects.

Table 5: Common Pests affecting Crops

Type of pest affecting crops	Frequency	Percentage
Caterpillars: stalk borers, white flies, worms, army worms, cut worms	81	84%
Rodents	42	44%
Aphids	30	31%
Termites and ants	25	26%
Weevils	24	25%
Fungus and bright	22	23%
Insects	15	16%
Viral	3	3%

Conditions that encourage pests to thrive

Regarding the factors that contribute to pests, two themes emerged namely farming practice and environmental issues.

Farming practices

Majority of the farmers pointed out that lack of knowledge for cultivation contributed to pests thriving in their farms. Some farmers did not observe best farming practices such as observing crop rotation, weeding at the right time and early planting. One farmer attributed this to the fact that small-scale farmers cultivate on small pieces of land which make it difficult to do crop rotation. Some communities were practicing monoculture which led to planting same crops on same piece of land. This is supported by a farmer (Admin, 2019) who advised others by explaining that:

“Growing maize alone is risky since a farmer can lose an entire harvest to diseases and pests. There is need therefore to explore other crops that can act as a buffer against hunger during the dry spell.”

One of the farmers indicated that due to the small sizes of land, he does not observe crop rotation which should reduce pests. The study also revealed that certain crops such as maize, being staple food crops, farmers had no option for other crops. Poor pest control in the neighboring farms contributed to increase in pests would migrate to neighboring farms. As one farmer observed;

“When I spray my farm to control pests and my neighbor does not do the same, the pests from their farms move to mine. Practices such as late planting, contaminated seeds, unsterilized farm tools and overgrown weeds were pointed as contributing factors to harbor some pests.”

Environmental factors

Some farmers stated that temperature changes contributed to pests. They stated that wind, heat, cold, wet weather, dry seasons, humidity, excessive rains, drought, dampness, and inconsistent rains contribute to pest breeding:

"Wet conditions force pests to seek a warmer place in the crops and dry conditions force pests to look for food from the crops."

Too much light or sunshine also force pests to seek shelter beneath the plants. This makes crops more vulnerable to pests.

"Fluctuating weather from extreme cold in the evening to morning and, excess heat during the day makes pests to thrive."

Some respondents stated that there is a disturbance in the ecosystem. One farmer stressed the point and said,

"We no longer have natural predators like chameleons, lizards, and spiders which used to eat pests."

Artificial and home-made pesticides used by farmers in Kenya

As shown in Table 6 the commonly used artificial forms of pesticides used by farmers were Actara, Actellic, Alphatox, Americal ball worm, Antac, Copex, detergent sprays, Diazinon, Doom, Dudu dust, Dudthline, Fuko Kill, Fungicides, Gladiator, Hervicides, Karate, Mexican Marigold, Milrazi, Ogor, Osho Powder, Profen, Pydist, Rat poison, Repellants, Rindomil, Rodenticides and Seven sprays. These can be categorized as insecticides, which kill or repel pests of insect category; Rodenticides which kill, reduce or repel rats, mice and moles. However, there were no reports use of herbicides which are used for killing or reducing weeds by the respondents.

The home-made pesticides comprised of the following: Aloe vera, Ashes, biological controls, Vitter yellow flowers, cloves, herbs, Marigold plant, Mubangi, Need Indica, Pepper, Rabbit urine, Salt and Solanum apple. Similarly, these remedies were used to kill, repel or reduce insect related pests and rodents.

Table 6: Commonly used artificial and homemade pesticides

Commonly used artificial pesticides used by farmers	forms of	Home-made pesticides or control measures used to arrest pests
Actara		Aloe vera
Actellic		Ashes
Alphatox		Biological controls
American ball worm		Bitter yellow flowers
Antac		Cloves
Coopex		Herbs
Detergent sprays		Marigold plant
Diazinon		Mubangi
Doom		Neem Indica
Dudu dust		Pepper
Duduthline		Rabbit urine
Fuko kill		Salt
Fungicides		Solanum apple
Gradiator		
Herbicides		
Karate		
Mexican Marigold		
Milrazi		
Ogor		
Osho powder		
Profen		
Pydist		
Rat poison		
Repellants		
Rindomil		
Rodenticides		
Seven sprays		

Types of agricultural pest control methods used by farmers

Regarding usage of pesticides as reflected in Table 7, the study revealed that the majority 80% of the respondents used artificial pesticides followed by those that were using home-made pesticides 68% and those that were using a mixture were the least with 65%. This suggest that the respondents' most preferred remedy for pesticides was artificial pesticides followed by home-made pesticides.

Table 7: Common agricultural pest control methods used by farmers

Category of pesticide	Very much used	Much used	Not sure	Not used	Not used at all	Total
Home-made made pesticides	30%	38%	14%	11%	6%	100%
Artificial pesticides	44%	36%	6%	11%	3%	100%
Mixture of artificial and home-made made pesticides	20%	45%	16%	9%	9%	100%

Effectiveness of Methods of controlling Pests

According to Table 8, 79% of the respondents stated that the use of artificial pesticides was the most effective method to control pests, then 63% stated that mixture of artificial and home-made pesticides was effective and finally 62% stated that home-made pesticides were effective. This finding suggest that majority of the respondents perceive that artificial pesticides are more effective than home-made and mixture of artificial and home-made pesticides.

Table 8: Effectiveness of pest control methods used by farmers in Kenya

Method of pest control	Very effective	Effective	Not sure	Not effective	Not effective at all		
Home-made pesticides	9%	53%	23%	11%	5%	100%	
Artificial pesticides	27%	52%	8%	8%	4%	100%	
Mixture of artificial and home-made made pesticides	19%	44%	31%	3%	3%	100%	

Discussion

Environment

The fact that respondents observed increase in use of fertilizers can be explained by a FAO report which detected that cultivation of cereals on the same land without addition of organic or inorganic fertilizers leads to low yields, which in turn lead to inability to afford the purchase of inputs (Rapsomanikis, 2015). Farmers have been consistently and steadily increasing nitrogen application rates (Sheahan, Black, & Jayne, 2012). Perhaps the fact that majority of farmers had small pieces of land means that farmers were intensively using the same piece of land which result to depletion of nutrients hence the need for fertilizers. Overuse of land without resting perhaps make it a good breeding ground for pesticides. Ironically, the presence of pesticide should lead to reduced apiary activities. However, the observed increase in apiary activities suggests the presence of foliage and flowering plants.

Crops grown, and mostly affected by pests in Kenya

Most small and medium scale farmers practiced subsistence farming. Most of these crops were vegetables, cereals, fruits. This concurs with FAO report which observed that small and poor farmers, who may not be fully integrated in markets, choose to produce their main staple but also diversify their production to achieve better diets (Rapsomanikis, 2015). (D'Alessandro, Caballero, Lichte, & Simpkin, 2015). Perhaps this explains why only a few of the small-scale farmers in our study were involved in cash crops and maize and beans were among the most grown crops. This also concurs with Maize, (Zea mays) is one of the most important food and cash crops for both commercial and many rural farm families in Africa Interestingly, there was a relationship between crops and pesticides infection. Crops

mostly grown by farmers were the most affected by pests. Maize is mostly grown in Kenya. (Midega, Pittchara, Pickett, Hailua, & Khana, 2018)

Common agricultural pest species and state of crops affected

Pests were majorly indicated as insects and rodents. It was observed that crops were also infested by fungus, viral infections. Several studies indicate common pests that affect the major crops like maize as follows: Stalk borers (*Busseola fusca*), African armyworm (*Spodoptera exempta*), Seedling weevils (*Tanymecus* spp. & *Mesokeuvus* spp), Larger grain borer (LGB) Weevils Moths, Red flour beetle, Dried bean beetles, Grey leaf spots (GLS), Maize streak virus, Northern leaf blight, Maize streak virus (MSV) (*Cicadulina mbila*), Leaf rusts (*Puccinia sorghi*), Leaf blights (*Helminthosporium turcicum* and *maydis*) and Common smut (*Ustilago maydis*)(Ministry of Agriculture, Livestock, Fisheries and Irrigation National Agricultural and Rural inclusive Growth Project (NARIGP), 2018)· (D'Alessandro, Caballero, Lichte, & Simpkin, 2015). This is important to note that pesticides were used to kill pests and to treat infections. The common pests were those that affected crops in the farms and during storage. This is an important finding which relates to the farming practices mostly used by small scale farmers.

Environmental conditions that encourage pests

The study established that farming methods and changes in the environment contributed to thriving pest. This finding suggests

Composition of homemade and artificial forms of agricultural pest control methods are mostly used.

Majorly farmers used artificial pesticides compared to home-made. This observation could be because artificial pesticides are readily available in the Agro-vets and are precisely easy to use. It is interesting to note also that quite a good percentage of farmers use mixture of home-made remedies and artificial forms of agricultural pesticides. This can be explained perhaps by the fact that small scale farmers have tendency to use locally available pesticides which have no monetary cost. Once the locally available strategies do not yield positive results farmers then move to artificial remedies. Several studies have provided the home made remedies that can be used to address pests such as a report by NARIGP (Ministry of Agriculture, Livestock, Fisheries and Irrigation National Agricultural and Rural inclusive Growth Project (NARIGP), 2018). However, the extent these remedies are used in not known.

Effectiveness of agricultural pest control methods used in Kenya

Regarding effectiveness of pest control methods, there is no clear cut as which ones are more effective than the others among home-made, artificial and integration of the two. This suggests the dilemma of farmers to commit to one type of method. However, it is interesting that quite a significant percentage of the farmers opined that mixture of artificial and home-made were effective. This suggest that small scale farmers use integrated pest control to a certain level. Perhaps they have the advantage of size of the farms compared to large-scale farmers who may find difficulties to deploy homemade pesticides for the large farms.

Strategies of improving the methods

Regarding suggestions to improve pest control four themes emerged namely adoption of integrated pest management, adoption of organic farming, training on best practices of agriculture, and adoption of communal approach to pest control.

Adoption of integrated pest management

Farmers proposed that there is need to use a mixture of home-made pest control measures and artificial agricultural pesticides which are not harmful to the fauna and flora. Among the local measures were ashes and chilies to control insects such as aphids in vegetables.

Training on best practices of agriculture including organic farming

Farmers should be given information on the best pesticides and how to use them for optimal performance such as planting at the right time of the season, crop rotation, using push and pull technology, improve physical barrier to keep away pests, proper storage, weeding, practice of biological technologies, weeding at early stage, by using those that are friendly to the soils and the environment, drying the crops well before storage. Farmers proposed using organic methods of farming such as planting pest repellent varieties of crops to protect crops that are prone to be affected by pests. Trained extension officers should educate farmers in new pests and proper pest control methods.

Awareness on homemade pesticides and artificial pesticides

Farmers proposed creation of awareness on homemade pesticides and what they are used for. To that effect there is need to document the homemade remedies, how they are made, how they are used and on what pests they are used on. Furthermore, it would be important to document the level of effectiveness. Secondly, farmers stated that there is need for awareness on artificial pesticides, especially accessibility,

how to use them, prescriptions, effects and effectiveness. It was also suggested that there is need to create awareness on fake pesticides that are circulating in the market.

Future Research

There is need to carry out more research on what works best where, scientific research to determine which crops are resistant to which pests. Second, there is need to document home-made pesticides and their associated pests that they kill, reduce or repel.

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