Case Study

Pesticides use in pest management: A case study of Ewaso Narok wetland small scale vegetable Farmers, Laikipia County, Kenya.

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ABSTRACT

Small scale farmers in Ewaso Narok wetland, Laikipia County in Kenya are largely horticultural farmers who apply pesticides for their vegetable management. The farmer's knowledge and practices on pesticide management was assessed employing a structured questionnaire and face to face interviews for 86 farmers purposively selected. The results showed that 60% of the farmers did not use protective clothing, 38.4% were not aware of dangers of mixing different pesticides chemicals while 97% had no formal training on pesticide management. Except for the 76% of farmers who were aware of the pesticides routes of exposure into human body, all others parameters associated with good pesticide practices ranged low (16-39 %) and were correlated to the farmer's socio-demographic attributes (age, education and gender). These included use of personal protective equipments (39%), reading pesticide labels before use (25%) among other practices. The general poor pesticide practices among farmers in the wetland calls for an immediate comprehensive measures of reducing pesticide exposure and mitigating effects on human and environment. Adoption of good agricultural practices (GAP) and further study on

pesticide residue levels in agricultural food crops produced from the study area is recommended.

Key words: Ewaso Narok, wetland, synthetic pesticides, pest management,

INTRODUCTION

Pesticide use brings a lot of benefits to farmers including preventing and controlling losses due to pests and diseases attack, increased nutritional value, crop quality and better return on investments (Damalas and Eleftherohorinos, 2011). However, serious concerns on pesticide toxicity effects on human health have been raised (Asogwa and Dongo, 2009; Kikiwete *et al*., 2015 and EFSA, 2016). This is as a result of occupational exposures when handling pesticides and non-occupational exposures by consuming food with high levels of residues (Damalas and Eleftherohorinos, 2011). Easy access to pesticides by unauthorized individuals has led to accidental poisonings (Macharia *et al*., 2013 and Tsimbiri *et al*., 2015). Farmers in developing countries are at the highest risks of pesticide exposure due to unsafe pesticide management practices (Hakeem *et al*., 2016; Jallow *et al*., 2017). Their ignorance and inadequate training on safe pesticide practices are some of the major contributing factors (Ouédraogo *et al*., 2011; Chowdhury *et al*., 2012; Mengistie *et al*., 2015). Despite the dangers posed by pesticides there is still poor knowledge on correct dosages, safety intervals, application techniques and necessary precautions to be undertaken during pesticide use pesticide product's chemical formulations, physical states (liquid or solid), type of package, weather condition (Halimatunsadiah *et al*., 2016). Local and international bodies have set up standards of pesticide use with some levels of uncertainty since majority of pesticides may not be safe under all circumstance (Caspell *et al*., 2006) (EFSA, 2014(Damalas and Eleftherohorinos, 2011). Ewaso Narok is one of the main source of horticultural produce in Kenya for local and international markets (Mwita *et al*., 2012). The approximately 12km^2 coverage is a semi-arid grass land (Longitude 36^{o}12'17'' to 36^{o}45'16''E and Latitude 0^{o}28'51''N and 0^{o}7'28''S) with an altitude ranging 1780 to 1835m ASL and receives less than 500mm rainfall annually (WARMA Rumuruti weather station 2014). The wetland is riverine with a rich biodiversity of flora and fauna (Thenya, 2001). Horticultural farming is highly pesticide dependent with no exception of Ewaso Narok wetland (Thenya, 2001). This study was called for to provide insight on the pesticide practices including the use of protective clothing and equipments, pesticide storage, mixing of pesticides and disposal methods within the wetland.

MATERIAL AND METHODS

Field survey was conducted in the months of May to August, 2016 using a pre-tested structured questionnaire consisting of both open and closed ended questions based on the study by Ansam and co-workers (Ansam *et al*., 2010). A total of 86 vegetable farmers were purposively selected from the study area. The inclusion criterion was farmers who applied pesticides and had consented for the study. Data on farmer's socio-demographic

characteristics and pesticide management practices was collected coded, and analyzed using SPSS version 22. Kruskal-Wallis and Mann-Whitney tests were used to correlate between socio-demographic information and the pesticide practices with significance taken at 95% confidence level ($p<0.05$)

RESULTS AND DISCUSSIONS

Farmer's socio-demographic information

Table1 presents the socio-demographic information of 86 farmers. Farmers constituted 81.4% male and 18.6% female. Most farmers (62.8%) were of the age bracket 31-50 years, while 22.1 and 15.1% of farmers were of the age ≤30 and >50 years, respectively. Literacy was noted among the farmers as 66.3% had attained at least secondary school education, 29.1% were semi-illiterate (primary education) while 4.7% were illiterate (no formal education). These results are comparable to 80 and 55% literacy levels reported by (Shafiee *et al*., 2012) and (Mengistie *et al*., 2017), respectively. Adeola (2012) in a similar research found that 92.2% of farmers were in the age bracket of 25-55 and 7.8% were above 55 years. According to Adeola, 93% were male, 7% female, 63.3% had at least primary education while 12.5% had no formal education.

Table 1: Socio-demographic information of small scale vegetable farmers in Ewaso Narok wetland

Item		Frequency (F)	Percentage (%)
Education (N= 86)			
Illiterate (unable to read and write)		4	4.7
Primary (class 1-8)		25	29.1
Secondary level (A- level or form1-4)		40	46.5
Tertiary (colleges or university)		17	19.8
Age (years) (N= 86)	**Gender**		
≤30	Male	17	19.8
	Female	2	2.3
31-50	Male	48	55.8
	Female	6	7
>50	Male	10	11.6
	Female	3	3.5

Farmer's knowledge on pesticide practices vis a vis their socio-demographic information

Table 2 and 3 shows farmer's knowledge on various pesticide practices and significance of farmer's socio-demographics on pesticide practices, respectively.

Table 2: Farmer's knowledge of various pesticide practices

Practices	Yes (%)	No (%)
Knowledge of crop pests by name	75	25
Knowledge of crop diseases by name	75	25
Knowledge of pesticide products by name	89	11
Reading / interpretation of pesticide labels before use	20	70
Observation pesticide safety intervals (REI and PHI)	49	51
Knowledge of pesticide routes into the body	76	24
Usage of any PPEs during pesticide application	39	61
Knowledge of pesticide effects on human health	89	11
Knowledge of pesticides affects to environment	38	62
Knowledge of pesticides affects to aquatic life	8	92
Formal training on pesticide management	3	97

REI – re-entry intervals, PHI- pre-harvest interval

Table 3: Significant influence of farmer's socio-demographics on pesticide practices.

Pesticide practices Variables	p-value		
	Kruskal-Wallis test		Mann-Whitney test
	Age	Education	Gender
Mixing of different pesticide products	0.211	0.490	0.519
Rate risk of exposure during pesticide application	0.004	0.031	0.248
Knowledge of the routes of pesticide entry into the body	<0.001	0.007	0.029
Use of protective clothing during pesticide handling	0.007	0.005	0.132
Practices of alternative pests control mechanisms	1.000	1.000	1.000
Pesticide storage before and after use	0.757	0.074	0.007
Use of pesticide containers for other purposes	0.333	0.597	0.003
Disposal methods for pesticide containers	0.622	0.022	0.140
Observing pesticide safety intervals	0.273	0.009	0.208
Reading of pesticide labels before use	<0.001	0.003	0.482

α=0.05

The results showed that 76% of the farmers were aware of the entry routes of pesticides into the body including inhalation of vapours, dusts or mists, skin/ eye contact and ingestion. These entry routes were significantly dependent ($p<0.001$) on the demographic variables [age education ($p=0.007$), farming period ($p=0.014$) and gender ($p=0.029$). In relation to the use of personal protective equipment, 39% of the farmers indicated employing the practice although none of them committed to full gear. As such, respirators, hand gloves and face masks were not used during pesticide handling. This was attributed to the symptoms reported including headache (47%) and dizziness (20%) (Table 4). The underlying reasons for not using PPEs included; uncomfortabity (11%), inaccessibity (79%), and high cost (11%). The practice on PPE was significantly influenced by age ($p=0.007$), education ($p=0.005$) and farming experience ($p<0.001$). a similar findings were reported by Shafiee *et al*. (2012) in which dizziness (57.1%) and cough (44.3%) were the main pesticide poisoning symptoms while Jallow *et al*. (2017) reported headache (82%), dizziness (41%), nausea (49%) and skin problem (58%) among farmers after pesticide use.

While reading of labels on the pesticide package is a good practice, only 20% of farmers conformed to this. In-ability to read and understand were attributed to use of foreign language (60%), and small fonts (30%) sometimes used on the labels. Ability to read and interprets information on pesticide products labels was found to be significantly influenced by the farmer's age ($p=0.001$) and education ($p=0.003$). About 49% of the farmers were aware of the two pesticide safety intervals such as re-entry interval (REI) and pre-harvest interval (PHI). Cocktail mixtures were employed by 35% of the farmers with a fear on pesticide exposure noted since almost all farmers (96%) prepared the mixtures with no attention to the compatibility of different chemicals. The practice was significantly dependent on the farming experience ($p=0.013$). Disposal practices of pesticide empty containers were reported to include burying (54 %), burning (23%) and throwing in the open fields (16%).

At the time of the survey, 59% of the farms were under tomatoes (*Solanum lycopersicum*) production while 57% had tomatoes intercropped with kales (*Brassica oleracea var. sabellica*). Most farmers (75%) correctly listed some of the pests and fungal diseases that were affecting tomatoes and kales productions in their farms as shown in figures 1 and 2, respectively. However, 25% of farmers could not correctly name pests and diseases that continue to pose a challenge to them. vegetable crops are prone to pests and disease invasion, hence their production heavily depends on pesticide usage (Yalçin and Turgut, 2016). Knowing the type of pests is important to the farmer as it determines the type of pesticide (insecticide) to be acquired and used. Some farmers could not differentiate between diseases and pests thus they kept referring to the pests or diseases in Swahili language as *dudu* or *magonjwa*. Furthermore, Farmers with primary education and below could not differentiate between pests and diseases. For instance, some farmers referred to *Tuta absoluta* (currently known as *Scrobipalpuloides absoluta*) as a new diseases showing difficulties to correctly identify crop pests from diseases. A similar results

reported by Mengistie *et al*. (2015).Correct identification of crop pests and diseases is considered important especially to a farmer when choosing which pesticide to use for what pest or disease. This prevents guess work during the choice of pesticide thus preventing pesticide misuse. Some pesticides are also highly specific and systematic thus may not help much when applied on the crops for the purpose of controlling or preventing a disease that it is not meant for. The choice of pesticide used in the crop field need to be based largely on the type of pests and diseases in the crop field or neighboring fields. Omolo, (2011) list the common horticultural pests mentioned by farmers during his study in rift valley and central Kenya as thrips (19%), aphid (23%) and mealy bugs (23%) among others. Halimatunsadiah *et al*. (2016) and Moncada (2001) reported several insects pests namely cutworms, thrips, aphids, caterpillars, leafminer and diamond back moth.

Poor pesticide storage practices were common among farmers as 36% stored pesticides in their residential houses, 24% in store rooms (within the house, hanged on the roof or walls or stored under the beds (12%). Majority (63%) stored pesticides together with other farm tools such as knapsack sprayers and water pumps in the small structures built within the farms where farmworkers lived sometimes with their families. Store rooms, wall or roof hangings are areas which can easily be accessed by most family members especially children. Hence, this presented the risks of accidental or suicidal pesticide exposures among the family members. Furthermore, storage of pesticides in the farm structures together with farm tools was not a good practice as these structures acted as dwelling places by some of the farmers making them vulnerable to pesticide exposure effects. Possibly due to inadequate training, 80% of farmers could not relate any serious health condition to pesticide poisoning. Although, young and educated farmers (< 50 years) were more knowledgeable and receptive to safer pesticide handling practices, older farmers (>50 years) on the other hand, were reluctant to accept new agricultural practices. This findings concurred with the findings of a similar research carried out by Bond *et al*. (2007) and Mengistie *et al*. (2015). Better pesticide practices were recorded by the farmers with at least secondary education as opposed to those with primary education or no formal education at all. Similar findings were reported by Wandiga (2001) and Yassin *et al*. (2002) in their studies, respectively. Farmers who had little or no formal education could hardly read and interpret information on the pesticide product labels. This was a major contributing factor that led to the wide spread unsafe pesticide practices observed. Unfortunately, educated farmers who were well informed on the best pesticide safety practices were equally reluctant to read the package labels and to put the knowledge into practice.

World Health Organization (WHO) and Agricultural Food Organization (FAO) recommends that any person handling pesticides must be trained on sound pesticide practices (FAO/WHO, 2014). In the current study, 97% of farmers had no formal training to enhance their knowledge and understanding on safe pesticide practices. Millard *et al*. (2004) concluded in their study that formal training is responsible for the enhancement of most farmer's knowledge on pesticide safety. Mixing of pesticides were done without considering the compatibility of the pesticide ingredients. Given that, pesticide labels do

not contain information on the mixing or using of pesticides as a cocktail mixture. Mixing chemicals could present adverse effect on human health and environment. Furthermore, the efficacy and activity of the individual pesticides could not be guaranteed due to incompatibility issues and possible chemical reactions. Evidently, Hamby *et al*. (2015) reports that copper (II) catalyzes the breakdown of organophosphate insecticides when mixed together thus greatly reducing their efficacy and activity. Equally, it is dangerous to mix both emulsified concentrates (EC) and Wettable powder (WP) before application. It was observed that in most cases mixing of the chemicals was done using long sticks with no proper protective clothing or equipment further enhancing pesticide exposure through skin contact, inhalation or even ingestion of contaminated food and cigarettes. Pesticide safety procedures were not observed starting from the point of storage, mixing, spraying and disposal of pesticide empty containers. Pesticide empty containers were sported thrown all over in the trenches and farm proximity. Even those who reported to carryout disposal through burning or burying of waste did not follow the right procedure. Pesticide containers were buried without protecting the wastes from possible leaching into the underground water. Burning was done in the open further exposing the nearby workers to toxic fumes. This finding was similar to a study conducted by Jallow *et al*. (2017).

Unsafe pesticide waste disposal methods could results into increased contaminations of water and soil further increasing the risk of exposure to both human and wetland health. Re-use of pesticide containers for other domestic purposes was common further aggravating pesticide exposures in the area. Application of wrong pesticide dosage on the crops could not be ruled out as most of the containers used to measure pesticides were uncalibrated and poorly maintained. Risk of pests developing resistance to the chemical pesticide due to under-dose or increased vegetable phytotoxicity as a result of over-dose could not be ignored. These findings were similar to a study conducted in Kuwait by Jallow *et al.*, (2017).

Table 4: Acute pesticide poisoning symptoms reported by small scale vegetable farmers in Ewaso Narok wetland after pesticide application

Symptoms	Frequency(f)	Percentage (%)
Excessive sweating	2	2
Hand tremor	3	4
Convulsion staggering	1	1
Nausea / vomiting	1	1
Narrow pupils/ miosis	6	7
Blurred vision	3	4
Headache	40	47
Dizziness	17	20
Irregular heartbeat	2	2
Skin rushes	9	11

Sleeplessness/ insomnia	2	2

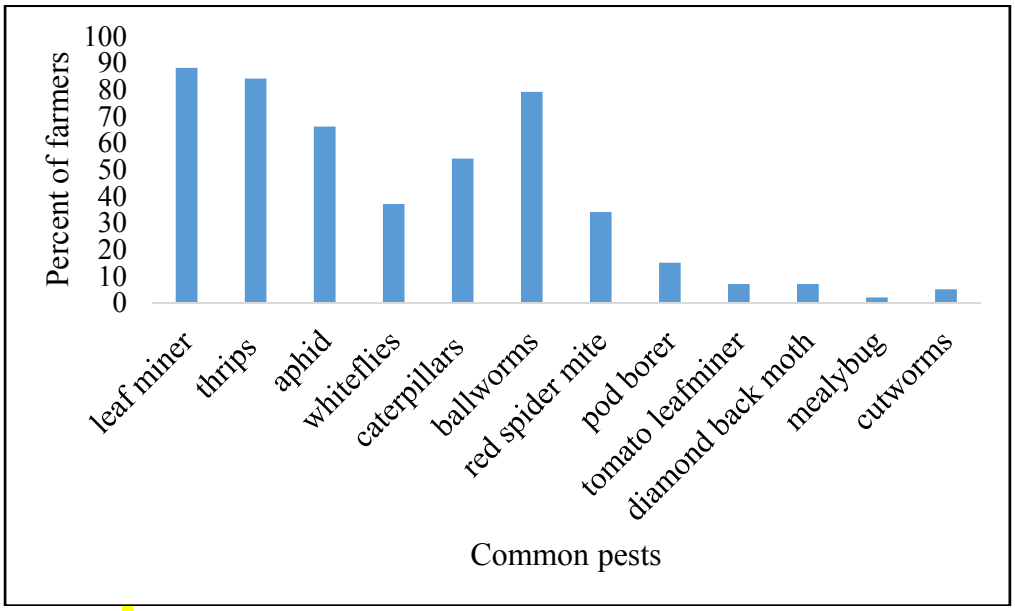

Figure 1: Common pests listed as a threat to tomato and kales production

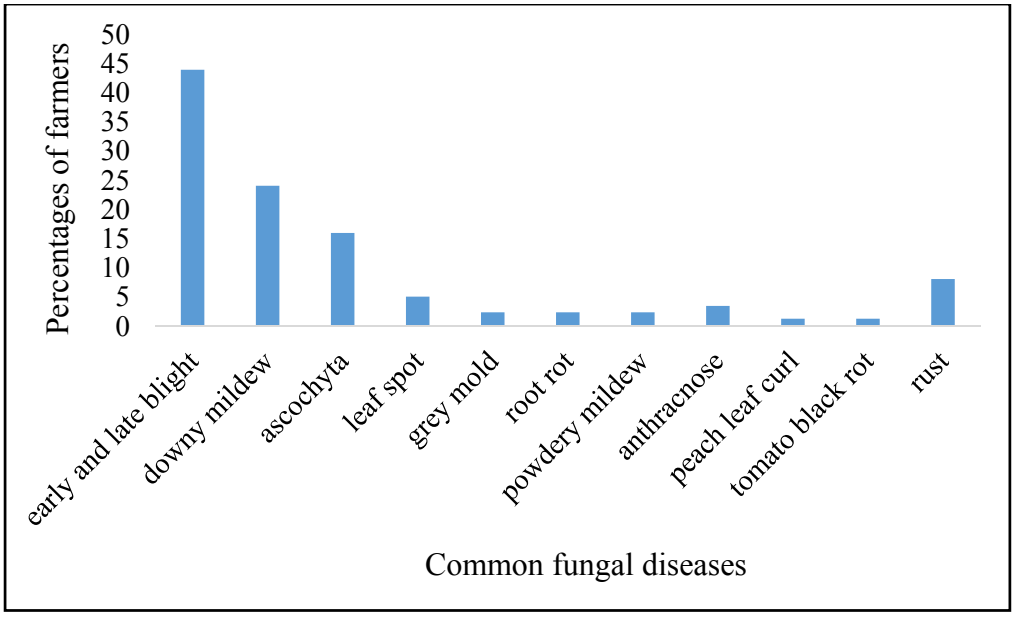

Figure 2: Common fungal diseases listed as a threat to tomato and kales

CONCLUSIONS AND RECOMMENDATIONS

Generally, poor pesticide practices was evident amongst the farmers. Inadequate training on sound pesticide practices and failure to adopt good agricultural practices (GAP) made

farmers more vulnerable to pesticide exposure. Mixing and spraying of pesticides was done without the use of adequate personal protective clothing and equipments (PPEs). Furthermore, environmental pollution through pesticide distribution routes such as leaching into the underground water and surface runoffs was evident. Farmers training on pesticide management practices, adoption of GAP and integrated pest management (IPM) are recommended. More agricultural extension officers deployment in the area is necessary. Further studies on the pesticide residues levels in agricultural produce from the Ewaso Narok wetland to determine the level of food safety is recommended.

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APPENDICES

APPENDIX 1: CONSENT FORM

Ewaso Narok wetland agricultural pesticides survey.

Name of the Respondent_____

Village _____ **County**_____**Mobile number:** _____

I Peter B.M. Otieno Ngolo (I56/CE/27737/2013) a student at Kenyatta University, undertaking Masters of Science project at Rumuruti wetland with an aim of evaluating the level of farmer's exposure on the sound pesticides management in terms of potential risks and safety. Determining the types/ range of pesticides used by farmers within the wetland and carrying out the screening of the levels of these pesticides residues within the wetland ecosystem. The results of this survey are solely meant for educational purposes and not for profit making and as such any **participation** on this study shall be purely on **voluntary basis** with **no financial benefits** attached. This study has been authorized by express permission of Kenyatta University Board of Postgraduate studies. I am inviting you to be part of this study. Your participation is voluntary and has no immediate financial benefits. The outcomes of this study will be shared with the farmers.

If you agree to participate in the study, you will be:

1. Asked questions about the types of exposure you have on sound pesticides management which include safety precautions, first aid mechanisms and waste disposal by means of filling or being assisted to fill in a questionnaire.
2. Requested to provide a list of pesticides that you use in your farm on different crops and the pest / disease they help control.
3. Requested to allow us pick Kales and soil samples from your farm for the laboratory analysis of the pesticides levels.

By signing this form you are consenting to be part of the study/survey. Should you need more information you can contact **Peter B.M. Otieno Ngolo, Tel. No: +254720627109.** If you change your mind about taking part in the study, you are free to do so but we encourage you to participate. If you wish, all your information will be kept confidential. Please let us know your preferred choice (Y) (N).

I declare that the study/survey team has given me all the information I need about the study in a language that I understand and that I have been given a chance to ask all the questions I may have had and that these have been answered to my satisfaction. I voluntarily consent to participate in the study/survey.

_____

Name of the person giving consent Signature Date

_____

APPENDIX 2: FARMER'S QUESTIONNAIRE

SECTION A: PERSONAL DETAILS

KENYATTA UNIVERSITY	Ewaso Narok Wetland Agricultural Pesticide Study	
	Farmers questionnaire	Farm code:
		Date: Enumerator

Farmer's level of education: Sex: Age:

SECTION B: RESOURCE UTILIZATION AND PRODUCTION

1. What is the approximate size of your farm in acres? 0 – 1ha ☐ 1 – 5 ha ☐ over 5 ha ☐
2. For how long have you been farming? Less than 1 year ☐ 1year ☐ 2- 5 years ☐ 5 – 10 years ☐ 0ver 10 years ☐
3. What types of crops do you plant in your farm? (Maize, kales (Sukuma wiki), spinach, tomatoes, cabbages etc.) Maize ☐ Kales (Sukuma wiki) ☐ Spinach ☐ Cabbages ☐ Tomatoes ☐ f) French beans ☐ Others specify
4. How long have you been using pesticides on your farm? 0 – 2 years ☐ 2 – 5 years ☐ 5 – 10 years ☐ Over ten years ☐
5. At what stage of crop life do you apply the pesticides? During planting, ☐ weeding ☐ storage) ☐
6. Have you ever received formal training on pesticide practices? Yes ☐ No ☐ if you have not received any training, do you have access to someone who provides such training? Yes ☐ No ☐ If YES, who?
7. When you buy pesticides, does it happen sometimes that the container(s) has no label? Never happen ☐ It does happen sometimes ☐ Often ☐ I don't know ☐
8. What influences your decision while choosing pesticide to use on your crops/ farm Supplier (vendors and Agrovet) ☐ Commercial sources of information

(advertisements, labels on the container) ☐ Fellow farmers ☐ Income ☐ media ☐

9. Do you mix different brands of pesticides before application? Yes ☐ No ☐
10. What is the main reason why you mix the pesticides this way? Unsure about the quality of pesticides ☐ Uncertain about the effectiveness of pesticides for a particular pest ☐. Advice by retailers/ suppliers ☐ Following the suggestion of others ☐ Other reason (please specify)
11. What kind of chemical means of plant protection (pesticides) have you been using, for which crops, pests /diseases, and how much?

Product/trade name	Frequency daily/Weekly/ monthly	Which crop being treated	Target/pest weed/ disease	Results

12. Who is the main person with the responsibility of applying the pesticide in the farm?
    Respondent ☐ Farm owner ☐ other family members ☐ Hired applicator ☐
13. On a scale of 1-5, how much risk do you think you are exposed to while using pesticides on this farm? No risk at all ☐ Some small risks ☐ A medium amount of risk ☐ A large and significant amount of risk ☐ Dangerous and very toxic risks ☐ I don't know ☐
14. Do you know how pesticide chemicals can get into your body system (routes) Yes ☐ No ☐ If yes please give examples (inhalation, skin contact, oral, etc.?)
15. Do you wear protective clothing when applying pesticides? Yes ☐ No ☐
    If no why? Please pick one: too expensive ☐ not available ☐ uncomfortable ☐ If yes, check one or more of the following;

PPE	YES	NO	I DON'T KNOW
Gloves			
Face masks			
Overalls			
Eye glasses			
Boots/shoes			
Long pants			
Long sleeve shirt			

Respirator			

16. How do you apply the pesticides on your crops? With hand pump ☐ with tractor ☐ with brush ☐ with leaves ☐
17. Do you currently practice any pest control techniques to reduce the need of using pesticides? Yes ☐ No ☐ If YES, which methods do you use: Organic production ☐ Biological control ☐ Mechanical-physical techniques ☐ Rotation of crop ☐
18. In your opinion, can you rate how harmful the chemical (synthetic) pesticides are for the environment and health? If yes, please specify; not harmful ☐ moderately harmful ☐ Very harmful ☐
19. When using pesticides or being exposed to them have you experienced (check one or more of the following):

Symptoms	**Yes**	**No**	**I don't know**
Excessive sweating			
Hand tremor			
Convulsion Staggering			
Excessive salivation			
Narrow pupils/miosis			
Blurred vision			
Headache			
Dizziness			
Irregular heartbeat			
Skin rashes			
Diarrhea			
Difficulty breathing			
Sleeplessness/insomnia			
Nausea/vomiting			

20. How do you store pesticides before and after use? in their original containers ☐
    In my own containers ☐ in my storage room ☐ in the house ☐ farm house ☐ others …….
21. Are the pesticide containers used for other purposes afterwards? Yes ☐ No ☐
    If yes, are you aware that you should not do this? Yes ☐ No ☐
22. How are the containers or packages disposed of? Thrown in open field ☐
    Buried ☐ Burnt ☐ Put in rubbish/trash ☐
23. From whom do you receive consultations about the right use and storage of pesticides? From retailer ☐ from consultancy services ☐ from fellow farmers ☐ others (please specify)
24. Are there agricultural extension services in Rumuruti? Yes ☐ No ☐
    If yes, are the service or advices by these extension officers available to you?
    Yes ☐ No ☐
25. How many times do you apply pesticides in your farm crops before harvesting?
    Once ☐ twice ☐ thrice ☐ more than thrice ☐
26. Do you observe pesticide safety intervals? Yes ☐ No. ☐ If yes, list the pesticide safety intervals
27. Do you read the label of pesticide product container before use? Yes ☐ No ☐
28. Rate the effectiveness of pesticide use in your farm Excellent ☐ Good ☐
    Fair ☐ Poor ☐