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Pesticides Use in Pest Management: A Case Study of Ewaso Narok Wetland Small-scale Vegetable Farmers, Laikipia County, Kenya

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Authors' contributions

This work was carried out in collaboration between all authors. Author NP designed the study, carried out fieldwork, performed the statistical data analysis and wrote the first draft of the manuscript. Authors NM, MA and OH managed the literature searches and analyses of the study. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Small-scale farmers in Ewaso Narok wetland, Laikipia County in Kenya are mainly horticultural farmers who apply pesticides for their vegetable management. A structured questionnaire was used to assess farmer's knowledge and practices on pesticide management on 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 in pesticide management. Except for the 76% of farmers who were aware of the pesticides routes of exposure to the human body, all others parameters associated with good pesticide practices ranged low (16-39%). Farmer's pesticide practices correlated to the farmer's socio-demographic attributes (age, education, and gender).These included the use of personal protective equipment (39%), reading pesticide labels before use (25%) among other practices. The general poor pesticide practices among farmers in the wetland all for an immediate, comprehensive measure of reducing pesticide exposure and

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mitigating effects on human and environment. This study recommends adoption of good agricultural practices (GAP) and further investigation on pesticide residue levels in food crops produced from the study area.

Keywords: Ewaso Narok; wetland; synthetic pesticides; pest management.

1. 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 [1]. However, severe concerns about pesticide toxicity effects on human health have been raised [2,3,4]. The above concern is as a result of occupational exposures when handling pesticides and non-occupational exposures by consuming food with high levels of residues [1]. Easy access to pesticides by unauthorised individuals has led to accidental poisonings [5] and [6]. Farmers in developing countries are at the highest risks of pesticide exposure due to unsafe pesticide management practices [7,8].Their ignorance and inadequate training on safe pesticide practices are some of the major contributing factors [9,10,11]. Despite the dangers posed by pesticides, there is still inadequate 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, and weather condition [12]. Local and international bodies have set up standards of pesticide use with some levels of uncertainty since the majority of pesticides may not be safe under all circumstance [13,14,1]. Ewaso Narok is one of the primary source of horticultural produce in Kenya for local and international markets [15]. The approximately 12 km^2 coverage is a semi-arid grassland (Longitude 36°12'17'' to 36°45'16''E and Latitude 0°28'51''N and 0°7'28''S) with an altitude ranging 1780 to 1835m ASL and receives less than 500 mm rainfall annually (WARMA Rumuruti weather station 2014). The wetland is riverine with a rich biodiversity of flora and fauna [16], Horticultural farming is highly pesticide dependent with no exception of Ewaso Narok wetland [16]. This study was called for to provide insight on the pesticide practices including the use of protective clothing and equipment, pesticide storage, mixing of pesticides and disposal methods within the wetland.

2. MATERIALS AND METHODS

A Field survey was conducted in 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 [17]. A total of 86 vegetable farmers were selected purposively for the study. The inclusion criterion was farmers who applied pesticides and had consented to the study. Data on farmer's socio-demographic characteristics and pesticide management practices were collected, coded and analysed 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 ($p<0.05$).

3. RESULTS AND DISCUSSION

3.1 Farmer's Socio-demographic Information

Table 1 presents the socio-demographic data 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 training). These results are comparable to 80 and 55% literacy levels reported by [11,18], respectively. [19] in 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 training.

3.2 Farmer's Knowledge on Pesticide Practices Vis a Vis Their Socio-demographic Information

Tables 2 and 3 shows farmer's knowledge on various pesticide practices and significance of

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 socio-demographics on pesticide practices, respectively.

The results showed that 76% of the farmers were aware of the entry routes of pesticides into the body including inhalation of vapours, dust 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). About 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 unused during pesticide handling. These practices led to the symptoms reported including a headache (47%) and dizziness (20%) (Table 4). The underlying reasons for not using PPEs included; discomfort (11%), inaccessibility (79%), and high cost (11%). Farmer's age, education and farming experience significantly influenced the use of PPE giving a p-value of 0.007), 0.005) and <0.001 respectively. Similar findings were reported by [18], in which dizziness (57.1%) and cough (44.3%) were the main pesticide poisoning symptoms. Similarly, Jallow *et al.*[8] reported a 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. Factors that led to farmer's inability to read and understand included; the use of foreign language (60%), and small fonts (30%) sometimes used on the labels. Ability to read and interprets information on pesticide products labels were 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). About 35% of the farmers applied cocktail mixtures on their farms which led to fear on increased pesticide exposure since most (96%) farmers prepared the 'cocktails' with no attention to the compatibility of different chemicals. The practice was significantly dependent on the farming experience (p=0.013). Disposal practices of empty pesticide 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 Figs. 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 [20]. Knowing the type of pests is essential 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 the 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 disease showing difficulties to distinguish crop pests from diseases. Similar results reported by [11].

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 the environment	38	62
Knowledge of pesticides affects 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 exposure	<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

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. Thus, preventing guesswork and misuse of the pesticides. Some pesticides are also highly specific and systematic thus may not help much when applied to wrong crops to control or to prevent disease. The choice of pesticide used in the crop field needs to be based mainly on the type of pests and diseases in the crop field or adjacent fields. [21] lists the common horticultural pests mentioned by farmers during his study in the rift valley and central Kenya as thrips (19%), aphid (23%) and mealybug (23%) among others. [12,22] reported several insects pests namely cutworms, thrips, aphids, caterpillars, leafminer and diamondback moth.

Poor pesticide storage practices were common among farmers as 36% stored pesticides in their residential houses, 24% in storerooms (within the home, hanged on the roof or walls or stored under the beds (12%). The majority (63%) kept pesticides together with other farm tools such as knapsack sprayers and water pumps in the small structures built within the farms where farmworkers sometimes lived with their families. Storerooms, 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. These findings concurred with the results of similar research carried out by [11,23]. Better pesticide practices were recorded by the farmers with at least secondary education as opposed to those with primary training or no formal training at all findings which were similar to the results reported by [24,25], respectively. Farmers who had little or no formal education could hardly read and interpret information on the pesticide product labels. Thus, literacy was a major contributing factor that led to the widespread unsafe pesticide practices observed. Unfortunately, most farmers were reluctant to read pesticide package labels and to put the knowledge into practice including the well-trained farmers.

World Health Organization (WHO) and Agricultural Food Organization (FAO) recommends training of any person handling pesticides on sound pesticide practices [26]. However, in the current study, 97% of farmers had no formal training to enhance their knowledge and understanding of safe pesticide practices. [27] concluded in their study that formal training is responsible for the enhancement of most farmer's knowledge on pesticide safety. Mixing of pesticide products was carried out in disregard of the compatibility of the pesticide ingredients. Given that, pesticide labels do not contain information on using pesticides as a cocktail mixture; mixing chemicals could present adverse effect on human health and environment. Furthermore, it was difficult to ascertain the efficacy and activity of the individual pesticides due to incompatibility issues and possible chemical reactions. Evidently, [28] report that copper (II) catalyses the breakdown of organophosphate insecticides when mixed thus substantially reducing their efficacy and activity. Equally, it is dangerous to combine both emulsified concentrates (EC) and Wettable powder (WP) before application. In the 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. Inadequate pesticide safety procedures were evident from the point of storage, mixing, spraying and disposal of empty pesticide containers. Pesticide empty containers were sported thrown all over in the trenches and farm proximity. Even those who reported to carry out disposal through burning or burying of waste did not follow the right procedure. Pesticide waste containers disposed of through burying without considering the possibility of chemicals 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 [8].

Unsafe pesticide waste disposal methods could results in 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 be real. These findings were similar to a study conducted in Kuwait by [8].

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 rashes	9	11
Sleeplessness/ insomnia	2	2

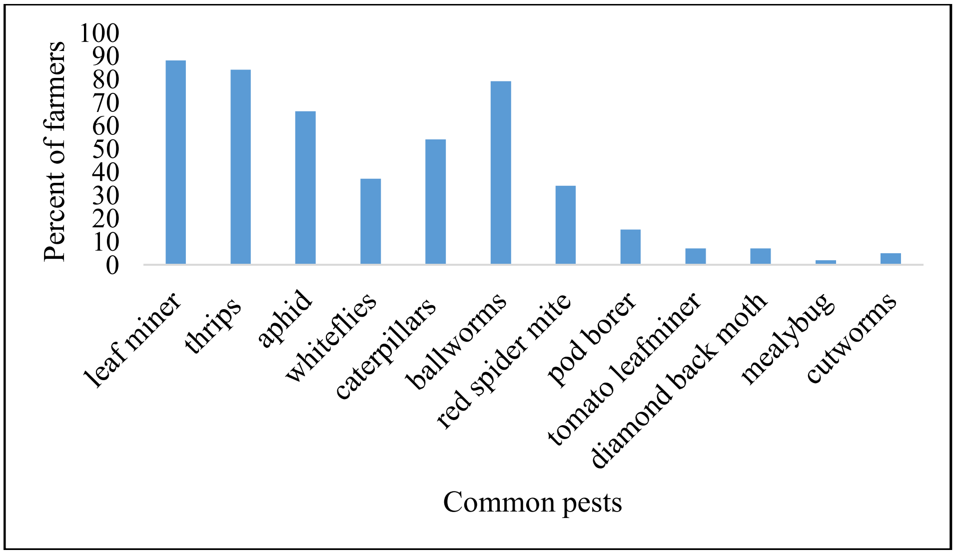

Fig. 1. Common pests listed as a threat to tomato and kales production

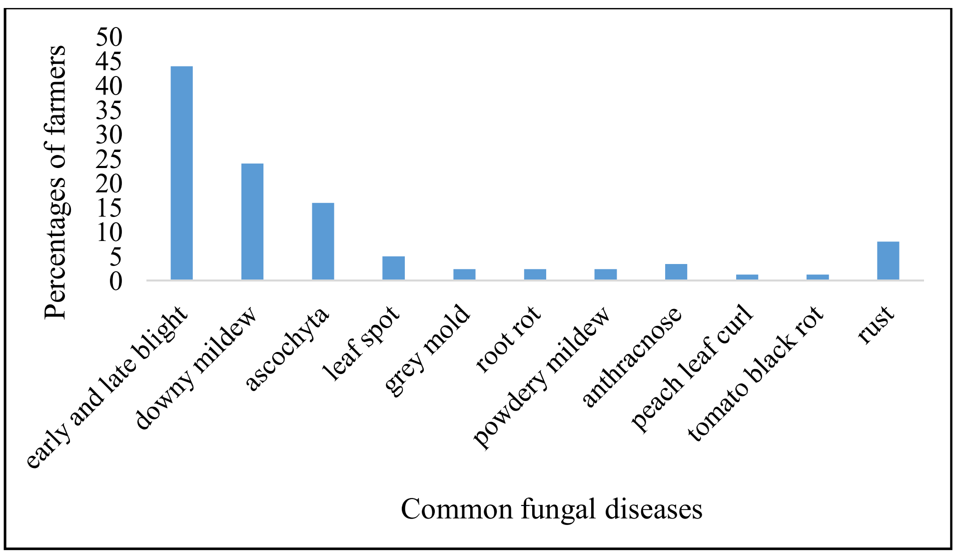

Fig. 2. Common fungal diseases listed as a threat to tomato and kales

4. CONCLUSIONS AND RECOMMENDATIONS

Poor pesticide practices were 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. The use of personal protective clothing and equipment (PPE) were inadequate during mixing and spraying of pesticides. 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. A recommendation is therefore made for further studies on the pesticide residues levels of farm products from the Ewaso Narok wetland to determine the level of food safety.

CONSENT

The inclusion criterion was farmers who applied pesticides and had consented to the study.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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