ASSESSMENT OF PESTICIDE USE AND APPLICATION PRACTICES IN TOMATO BASED AGROSYSTEMS IN KALILUNI SUB LOCATION, KATHIANI DISTRICT, KENYA

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Abstract
Pesticides are of great benefit to agriculture in Kenya by decreasing crop losses due to insects, weeds, plant diseases, rodents and other pests. They also save lives through control of disease carrying insects and increase the quality and quantity of agricultural produce. However, pesticides are poisons and can affect human health and contaminate the environment. This paper reports on the findings of an assessment of pesticide use, application and practices in Kaliluni, Kathiani district in Kenya. The dominant activity in the area is intensive irrigated tomato farming for local and other markets. Due to the sensitivity of the crop to pests invasion and abrupt changes in temperature pesticides and other agrochemicals are in rampant usage. The area has over 400 households that engage in tomato farming. A total of 72 households were involved in a cross-sectional survey to assess the pesticides usage, frequency of application, in small holder tomato production. Structured pre-tested questionnaires were administered through personal interviews and focused group discussion among the tomato farmers in the study site. The aim of the study was to establish whether banned or restricted pesticides were still in use. The study showed that the pesticides used in the region include pyrethroids, organophosphates and carbamates. It was found that 36.8% of the respondents used and applied pyrethroid formulated pesticides while 31.5 % applied carbamate based pesticides. It was also found that some respondents used more than one pesticide in one application. The study also showed that 26.4% of the respondents applied Dithane M45 (fungicide) as their main pesticide while 13%, 12% and 12% used Karate (insecticide), Ridomil (fungicide) and Bestox (insecticide) respectively. Surprisingly 1.9% of the respondents used and applied Dimethoate (insecticide) whose use has been restricted for use in fruits and vegetables while 0.5% used and applied Mocap (insecticide) which has also been banned. The farmers who used the banned chemicals claimed that they were more effective than the other pesticides. On the frequency of application of pesticides, the study showed that 86.1% of the respondents used pesticides on weekly basis whereas 12.5% apply fortnightly. The study therefore recommend that strict measures be taken to safeguard the environment and human health by the enforcing the law on use of pesticides.

Key words: Pesticides, carbamates, pyrethroid, dimethoate, Kathiani, Agrosystems**,** tomatoes

1.0 Introduction

Pesticides have been of great benefit to farmers because they decrease crop losses. The major impact of pests on crop agriculture is that they are the causes of reduced crop production, quality and consequently contribute to endemic poverty especially in developing countries (Nderitu *et al*., 2007). Pesticides are also known to cause environmental contamination, pollution and also kill non target beneficial organisms such as those useful in plant pollination (Nderitu *et al*., 2007). Of major concern is the fact that pesticides cause public health problems when residues are consumed in food products. Pesticides are associated with significant public health hazards, ranging from short-term impacts such as headaches and nausea to chronic impacts like cancer and endocrine disruption (Berrada *et al*., 2010). Due to use of more toxic pesticides, poor pesticides handling practices, inadequate management and regulation of these chemicals in developing countries by farmers lead to unprecedented public and environmental contamination (Gitonga *et al.*, 2010; Ntow, 2008; Waichman *et al*., 2007).

Pesticides can be classified according to their active ingredients namely; organochlorines, organophosphates, carbamates, pyrethroids, inorganics among others (Louis, 1994). Organochlorines are stable and slow degrading once applied and are soluble in fats thus accumulate in the adipose tissues of receptor organisms (Marthur *et al*., 2005). They are passed up the food chain where they bioaccumulate in fatty tissues. Organophosphates are more toxic than organochlorines though they are easily hydrolyzed but are highly toxic to invertebrates and insects (Chambers *et al.,* 2010). Carbamate insecticides are fat soluble and therefore are easily absorbed through the skin and then transported throughout the body. Carbamates are extremely toxic to bees and parasitic wasps (Liu *et al*., 2012). The World Health Organization (WHO) classifies pesticides in terms of their toxicity; as extremely hazardous (class IA), highly hazardous (class IB), moderately hazardous (class II), slightly hazardous (class III) and unlikely to present acute hazard (class IV) (WHO, 2008).

The potential of pesticides to cause both short and long term adverse effects to the environment as well as public health has attracted global attention. The Montreal Protocol of 1987 was designed to protect the ozone layer by phasing out ozone depleting substances like methyl bromide which is used as a soil fumigant. The Stockholm convention of 2001 banned the use of persistent organic pollutants (PoPs) due to their resistance to degrade, bioaccumulation in living organisms, and travel over long distance from the point of source and toxicity to animal and humans (Adelola, 2004; Fernandez and Grimalt, 2003; Scheringer and Wania, 2003; Stroebe *et al*., 2004; Ritter *et al*., 1995; UNEP, 2001). According to Basel convention of 1989, pesticides are considered to be hazardous substances and should be disposed of in an environmentally sound manner. The 1998 Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in

International Trade, aimed to reduce the environmental and health risks posed by Persistent Organic Pollutants. The legal notice number 120 of Government of Kenya on water quality prohibits pollution of water by discharging or application of any poison, toxic, noxious or other pollutant into aquatic environment. The National Environmental Management Authority (NEMA) is charged with the responsibility of promoting sustainable environment management however the Pest Control Product Board (PCPB) is mandated to regulate the importation, exportation, manufacture, distribution and the use of pest control products. However according to Wandiga (2001) some of the pesticides in spite of their ban or severe restrictions could still be available in the market in Kenya. A study done around Lake Naivasha basin showed use of banned or restricted pesticides like endosulfan under various trade names (Njogu, 2011). The Government of Kenya in 2012 banned the use of dimethoate on fruits and vegetables for both export and the local market (MOA, 2012).

A large proportion of fresh horticultural produce consumed in Nairobi is grown in the neighboring counties of Kiambu, Machakos and Kajiado (Odour *et al*., 1998). It is estimated that over 300,000 farm families earn the major part of their income through the cultivation and marketing of vegetables (Asaba *et al*., 2000). Kenya as one of the major horticultural producers in the world imports approximately 7,000 metric tons of synthetic pesticides worth 4 billion (KES) annually (US$ 50 million) (Birech *et al*., 2006). In as much as pesticides have ensured continuous supply of tomatoes, inappropriate use are a major concern due to environmental and health impacts associated with pesticides. Studies have shown build up of pesticide up the food chain and some levels of contamination of water, sediments, eggs, crops and human fluid by pesticides (Njogu, 2011; Wandiga, 2001). Kaliluni in Kathiani District, Machakos County, is an agricultural productive area faced with several environmental challenges among which are pests and diseases in tomato crop. The proximity of Kaliluni to the capital city of Kenya, Nairobi, creates high demand for tomato produce pushing farmers to harvest their tomatoes before the required withdrawal period and increased use of pesticides on tomatoes per season due to pests and disease resistance (Fabro and Varca, 2011; Litchtenberg, 2013). During the control of these pests and diseases farmers could be predisposing themselves to health risks due to inappropriate handling and use of pesticides.

This paper reports the pesticides used in tomato based agrosystem in Kaliluni, Kathiani District. This region supports a large horticultural industry both for export and domestic markets and this has consequently resulted into increased use of pesticides. Though a lot of work has been done on Pesticides in Kenya, no studies have been done on tomato production in Kaliluni area of Kathiani District to establish how farmers use and apply pesticides and especially for the production of tomatoes for the domestic market. A lot of emphasis has been placed on the vegetables produced for the export market. There is also lack of an inventory of

pesticides used in Kaliluni. The purpose of this study was to create and develop an inventory for the pesticides in use and to determine whether banned or restricted pesticides are in use. The study has provided useful information on this so often neglected source of negative impacts on human health and the environment, so that effective strategies to increase awareness regarding the use of pesticides in tomato based agro system can be developed (Haylamicheal and Dalvie, 2008).

2.0 Materials and Methods

2.1 Study Area

The study was conducted in Kaliluni, one of the administrative areas in Kathiani District approximately 20 kilometers from Machakos town and 150 kilometers from Nairobi, the capital city of Kenya. The area lies 01º 29.5754 S 037º 18.4983 E and receives bimodal rainfall ranging from 500 to 1100mm and the altitude ranges between 1700 to 2100 meters above sea level. The increased urbanization in Machakos town and Nairobi city has created high demand for tomatoes for the fresh domestic markets. The area is semi arid and favors survival and growth of pests and diseases pathogens which are a threat to crop production. The study area has approximately 400 tomato farmers growing tomatoes in the open field through irrigation. Other major agricultural activities in the area include; French beans production for the export market, dairy farming as well as coffee growing.

2.2 Study Design

The study was cross-sectional in nature and employed quantitative methods of data collection. Structured questionnaires, observations, check lists, focused group discussion and face to face interviews were used for data collection. The questionnaires were pretested to establish adequacy in obtaining the required information by targeting different respondents who were not part of the study population. Previsits to the study area were made to discuss the exercise with the relevant authorities. Respondents were informed of the purpose of the study and their consent obtained prior to administering the questionnaires. The study population consisted of all farmers growing tomatoes in Kaliluni.

2.3 Study Participants

The sample size was 72 farmers; determined using the following formulae.

$$nf = \frac{n}{1 + \frac{n}{Pop}}$$

Kaliluni sub location is made up of six villages. Participants were randomly selected from the six villages. The number of farmers participating per village was proportionate to the total number of farmers in a particular village. The study participants were household heads or any adult household member who was present in the home or farm at time of the study. Additional information was

obtained from purposively selected key informants, who included Agrovet dealers, Government agencies, village leaders and other key farmers.

2.4 Statistical Analysis

Data and information collected were coded, entered, and analyzed using Statistical Package for Social Science version 18.0 and Microsoft Excel.

3.0 Results and Discussion

The results of the study are presented in Tables and a Plate below.

3.1 Pesticide Used

The pesticides used and applied in the study area are presented in Table 1.0 and 2.0.

Table 1: Pesticides used and applied in the study area

S/No	Trade/COMMON Name of Pesticide	Chemical Classification of Pesticide	WHO Classification	Color Code	% Use
1	Dithane M45	Carbamate	Class IV	Green	26.4
2	Ridomil	Carbamate	Class II	Yellow	12.0
3	Oshothane	Carbamate	Class IV	Green	1.9
4	Karate	Pyrethroid	Class II	Yellow	13.2
5	Cyclone	Pyrethroid	Class II	Yellow	6.0
6	Milthane Super	Carbamate	Class II	Yellow	1.9
7	Bestox	Pyrethroid	Class II	Yellow	12.0
8	Dimethoate	Organophoshate	Class II	Yellow	1.9
9	Bulldock	Pyrethroid/Organophoshate	Class II	Yellow	0.5
10	Thiovit	Sulphur	Class IV	Green	0.5
11	Tata Alpha	Pyrethroid	Class II	Yellow	0.9
12	Milraz	Carbamate	Class III	Blue	7.4
13	Ortiva	Methoxyacrylate	Class II	Yellow	5.6
14	Decis	Pyrethroid	Class II	Yellow	1.4
15	Antracol	Carbamate	Class IV	Green	4.2
16	Daconil	Chlorothalonil	Class II	Yellow	0.9
17	Cuprocaffaro	Organophoshate	Class III	Blue	0.5
18	Mocap	Organophosphate	Class II	Yellow	0.5
19	Polytrin- P	Pyrethroid/Organophoshate	Class II	Yellow	0.9
20	No Pesticide Use	-	-	-	1.4
	TOTAL				**100**

Table 2: Percentage of Pesticides Used and applied in Kaliluni within WHO Classification

Who Classification	Percentage Within who Classification
Class IA and B	0
Class II	68.4
Class III	10.5
Class IV	21.1
Total	100.0

In the Table 1, 26% of the respondents said that they applied Dithane M45 which is carbamate while 13% of the respondents said that they used Karate which is pyrethroid. Carbamates and pyrethroid are safer pesticides but quite toxic to bees and parasitic wasps and their persistent use near plants pollinated by bees could significantly reduce their yields (WHO, 1986). The negative effect of carbamates on bees can result to reduced amount of honey harvested in the study area. On the classification of pesticides according to WHO, Table 2 showed that 68.4 % of the respondents used and applied class II of pesticides whereas 21.1% use class IV. This indicated that 68.4% of farmers used moderately hazardous pesticides, 10.5% of the respondents used slightly hazardous pesticides and 21.1% of the respondents applied pesticides which are unlikely to present acute hazard. When a high number of the respondents not only use class II pesticides (WHO) but they do not follow the instructors' manual. The human health and the environment could be adversely affected if their use is not as per the recommendation contained in the instructors' manuals.

3.2 Most Preferred Pesticides in Tomato Based Agrosystems in Kaliluni

Table 3 presents results on findings on preferred pesticides.

Table 3: Most Preferred Pesticides

Most preferred pesticide	Chemical classification	Frequency	Percent
Dithane M45	Carbamate	29	40.3
Dithane M45 and Oshothane	Carbamate and Carbamate	1	1.4
Cyclone	Pyrethroid	4	5.6
Ridomil	Carbamate	7	9.7
Oshothane	Carbamate	3	4.2
Karate and Dithane M45	Pyrethroid and Carbamate	1	1.4
Antracol	Carbamate	6	8.3
Karate	Pyrethroid	6	8.3

Milraz	Carbamate	3	4.2
Bestox	Pyrethroid	6	8.3
Daconil	Chlorothalonil	1	1.4
Decis	Pyrethroid	1	1.4
Thiovit	Sulphur	1	1.4
Ortiva	Methoxyacrylate	2	2.8
None		1	1.4
Total		72	100.0

Table 3, indicates that majority of the respondents, most prefer Dithane M 45 (40.3%), Ridomil (9.7%), Antracol (8.3%), Karate (8.3%) and Bestox (8.3%) in that order when applying on tomato crop. From the data shown in Table 3.0, over 68% of the respondents do use carbamates like Dithane M 45 , Ridomil or Oshothane as their most perefered pesticides. This could result to reduced yields to the cross pollinated crops like maize (Plate 1) which were found to be intercropped with tomatoes.

3.3 Frequency of Pesticide Use and Application

Data on frequency of use and application of Pesticides is presented in Table 4. Study indicates that, 86.1% of the respondents used pesticides on weekly basis whereas 12.5% use it after every two weeks. A very high number of the respondents, 98.6% applied pesticides more frequently.

Table 4: Frequency of Pesticide Use and Application in Tomato Based Agro systems in Kaliluni

application interval	Frequency	Percentage use
Weekly	62	86.1
Fortnightly	9	12.5
Other	1	1.4
Total	72	100.0

From the above table it clearly shows that most of the respondents do use pesticides. From the findings 98.6 % of respondents use pesticides. This percentage on use of pesticides is quite high.

3.4 Use of Banned and Restricted Pesticides

Banned and restricted pesticides were found to be used by farmers in the study area. As shown in Table 1.0 above, dimethoate use was 1.9% while mocap was 0.5%. Dimethoate pesticide is not supposed to be used on fruits and vegetables whether for local or export market. Mocap pesticide was banned due to its residual effect on soil organisms. Mocap can kill beneficial non target soil organisms while dimethoate can cause cancer. The continued use of banned pesticides could be due the availability of the pesticides on the shelves and the fact that they are quite effective.

3.5 Intercropping of Tomatoes with Other Crops

Plate 1: Farmers harvesting tomatoes

The above Plate 1 shows farmers harvesting tomatoes from their farm. The Plate shows tomatoes intercropped with kales and maize crops. The use of pesticides on tomatoes can have negative health effect on kales consumers. During pollination on maize crop the yield can be affected by use of carbamate pesticides which are toxic to bees.

Conclusion

From the findings of the study it is concluded that farmer use restricted and banned pesticides on tomatoes. The banned pesticides are dimethoate and mocap. This poses danger to the environment and human health. This was evident when farmers continue using pesticides on tomatoes in spite of their ban. It is also concluded that many farmers cannot grow tomatoes without the use of pesticides. The high use of carbamates and pyrethroid pesticides could have adverse effect on bees' pollinated crops or plants if grown on the same farm with tomatoes. Consequently this could result in reduced yield in cross pollinated crops.

Recommendation

On the basis of this study, the following recommendations are made;

That the regulatory institutions like the NEMA and PCPB should ensure that banned or restricted pesticides should not be used by farmers.

The regulatory authorities like NEMA and KEPHIS should monitor the quality of produce marketed locally and ensure that consumers are not exposed to high levels of pesticides residues in farm produce. The Ministry of Agriculture and Private Partners ought to train farmers on safe use of pesticides. This study recommends further research on the alternative methods to pests and disease control in tomato farming.

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