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Full Length Research Paper

Assessment of the knowledge and use of pesticides by the tomato farmers in Mwea Region, Kenya

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Current cultivation of vegetables to meet food security standards requires the use of pesticides which reduce losses from pests and diseases. A cross-sectional survey for pesticides use in tomato farms was conducted in Mwea, Kenya to assess the practices and constraints faced by the farmers. Gender, level of education, the use of pesticides in farms, experience in tomato farming, list of common pesticides, periodicity of pesticides spray in farms, approximate last day for pesticides spray, reason for pre-harvest period and pesticides spray in post-harvest time were investigated. Results revealed that, 90% farmers were men and 10% were females; 38.5% and other 38.5% attended primary and ordinary schools; 15 and 4% had advance and university levels. About 69% of respondents knew pesticides through other farmers; 31% through agrovets, extension officers and agricultural experts. Around 56% farmers knew the names of pesticides through other farmers, 44% got them from agrovets, agricultural officers and chemical companies. About 98% respondents use pesticides approved by government, 96.2% listed each between 2 and 11 names of pesticides mostly used in tomato farming. Almost 93% spray pesticides once a week in farms and 76.9% observe at least 7 days for the pre-harvest period. Relatedly, 84.8% assert that waiting for the pre-harvest time is the culture of farmers in the region. Surprisingly, 6% spray pesticides in the post-harvest period, while 84.6% assert that the pre-harvest moment is to avoid pesticides in post-reap. Although key questions found good answers from farmers, the quality of their knowledge is limited, shows missing information and needs reinforcement. Agrovets appear as the legal authority and act as key informants for most farmers. Most farmers rely on other farmers or agrovets-displacing the low or nonexistent contribution of agricultural extension officers. Capacity building and periodic updates for agrovets and farmers are required.

Key words: Pre-harvest, pesticides, organizational, awareness, appropriation, harmonization.

INTRODUCTION

Securing food to control hunger and food scarcity after the Second World War led the Food and Agriculture Organization (FAO) to adopt tools and measures for a permanent solution to the problem of production of raw food in agriculture. From the archaic to the modern agriculture, the use of pesticides in farms to control pests invading the area (such as *Tuta absoluta*, Thrips, Leave chlorosis, Mites, Nematodes, Bollworm) and diseases (Stem rot, bacteria wilt, early blight, late blight, leaf rust) on crops under food security program appeared as the ultimate solution. No matter the case, food remains the priority of the primary inevitabilities without which humans cannot survive (Caprihan, 1975). Current food is likely to contain chemicals and chemically contaminated diet is rather a soft and silent killer unconsciously taken voluntarily by the consumers. Pesticides adopted for crop protection become harmful as early depicted in the fifties by Rachel Carson (Peshin and Dhawan, 2009; Amuoh et al., 2011; Nunifant, 2011; Pujeri et al., 2015) if the farmers have little and incomplete information not only on their best use but also on the potential consequences of misuse (Mutai et al., 2015).

The intensive use of pesticides in tomato farms (Asante et al., 2013) seems to provide nice and best quality of produce at sight for the markets and makes good deals for both the farmers and vendors. But, this seems to have contributed in the increase of food hazards responsible for 200 diseases spanning from diarrhea to cancer and diabetes in humans (WHO, 2015). To reduce the risk to health from pesticides contaminated products and therefore to reduce the socioeconomic burden of diseases, the European Union (EU) has designed criteria on pesticides residues to meet the quality for a healthy diet. Also, the biological fight uses harmless pests to control. The retailers and consumers of the harvested produce have little or no relevant information. They are deprived of knowledge on contaminated food and have no idea, no capacities to either detect or act and take appropriate stands against chemically contaminated food. The solution for the raw tomato is to trace back information from the tomato farmers. The aim being to see whether the end tomato produce can be qualified without test as free of chemicals contamination in markets for instance and thus, safe for the consumers such as the city dwellers.

Tomato was introduced in Eastern Africa by the colonial power in early 1900 (Wachira, 2012). Real national interest on the horticultural crop for profit making started in the 1980s with the socioeconomic progress of one of the pioneer in Mwea-Kirinyaga (Muru, 2009). Tomato is actually cultivated in both open air and greenhouses. The major producing areas of the good include Mwea, Nakuru, Meru, Nyeri, and TaitaTaveta (Wachira, 2012). The produce is cultivated all over the national boundaries at an altitude 1150 and 1800 m above the sea. Almost 300,000 farm families earn the major part of the revenue through vegetable cultivation (Mutuku et al., 2014). In 2011, the area under tomato farming was around 19,000 ha from which 600,000 metric tons were harvested releasing an income of KES 14.2 billion (Mbaka et al., 2013).

Tomato is one of the most consumed and cultivated vegetables in the world eaten either raw or processed. The fruit is second in the worldwide productivity of vegetable with 458.2 million ha used for farming and 32.8 tons/ha (Abdulkareem et al., 2015). Tomato contains the P3 substance which prevents platelets clot and curbs death from heart diseases and strokes (Tarla et al., 2015). The fruit is the source of many antimutagenic, anticarcinogenic, anti-inflammatory and anti-allergic phytochemicals (quercetin, kaempferol and myricetin). New tomato varieties continue to be developed by plant breeders and geneticists (Dave, 2012). The markets are demanding best quality produce at sight. Tomato is now an important cash crop improving the leaving standards and creating employment (Shankara et al., 2005; Wachira et al., 2012). Therefore, looking to fulfill the needs of the families under the rampant poverty in farming areas, cultivators misuse pesticides in tomato ranches to keep the competitive level imposed by the demand. From this point of view, a survey was conducted in Mwea to assess farmers' practices on the use of pesticides in tomato farms, their knowledge on the chemicals, their quality of interactions with the chemical providers, as well as the whole chain included in the tomato industry from the ground production to the sales points including the processors.

MATERIALS AND METHODS

Study site

The study was purposively conducted in Mwea region situated in Kirinyaga County in the central province of Kenya. It is a region of small-scale tomato farmers partitioned into Mwea East and West. The population in Mwea is at around 150,000 persons. An estimate of 73% of the population is fully engaged in agriculture (Mwangi, 2014). The majority of dwellers are Kikuyu; Gikuyu and Kiswahili are the most spoken languages. Tomato production is a major business utilizing more than one third of the total cultivated land of the district. The district is among the four major production areas of tomato in Kenya (Mueke, 2007). The agricultural activities have profoundly transformed the region structurally and economically. Water flowing in the rivers is from Mount Kenya; this has always been of great interest for farming tomato in the area.

The locality is at about 100 km in the south east of Nairobi City. The district is bordered by latitudes 37°13'E and 37°30'E and longitudes 0°32'S and 0°46'S. The district is known as a tropical area with a semi-arid weather, the average annual temperature is

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approximately 23 to 25°C. This temperature differs by 10°C between the minimum noticed in June and July and the highest seen from October to March. The region is positioned at a high altitude at around 1,800 m above the sea and at 50 km south of the Equator (Muuru, 2009). Its climate is both cool and sunny; this provides natural good conditions for farming. The region has an annual average rainfall fluctuating between 1,000 and 1,800 mm (Ndiiri et al., 2013).

Experimental

A semi-structured questionnaire was designed for the collection of data from the tomato farmers. Preliminary field visit to Mwea was done for meeting with some agricultural extension officers for more information on the farming site. This included, the average number of tomato farmers, pesticides regularly used, the contribution of the business in the area and the challenges faced by the tomato farmers. Information was obtained through literature review and random semi-structure questionnaire to some researchers who conducted studies in the area. The Pests Control Product Board (PCPB) and Kenya Plant Health Inspectorate Service (KEPHIS) were visited for meeting with some experts. Some agrovets were interviewed in Nairobi to understand their implication in the management of pesticides with the tomato farmers. The tomato agribusiness in Kenya was also studied by meeting with some middlemen and tomato retailers.

The questionnaire was pretested in Kamulu and improved according to observations and findings after meeting with some tomato farmers. Some questions were discarded while others were added to fit with the understanding of farmers. An effort to obtain close or same results if the questionnaires are to be reproduced was made. A M.Sc. student was recruited during this field work for translation from English to Kiswahili and vice versa. The study was conducted in February and March 2017. Two key interviewers were recruited in Mwea and trained to administer the questionnaire. Consent and voluntary participation were always obtained from the interviewees after the introduction of the aim of the study. The interviewers were requested to collect data equally from both sides, Mwea East and Mwea West. The design effect was included during the recruitment and conversations with the farmers. Data were collected from the peasants who only cultivate tomato all year round and during all seasons. The number of farmers to interview was obtained on the basis of information given by the agricultural extension officers. The formula of Fisher was used with the tolerance limit sets at 10% significance (Mutete, 2005) on the basis of the estimated population fully engaged in agriculture in Mwea (Mwangi, 2014). The formula of Fisher was followed by the formula of Yamane (1967) and was modified as done by Inonda et al. (2015).

Reliability

The reliability of a questionnaire stands as its ability to reproduce similar results if the same questionnaire is repeated to the same participants under the identical situations on two diverse occasion and compare the scores (Melike and Ayten, 2013). This questionnaire was first pretested to know whether the farmers will be able to understand the questions. Secondly, pretesting also served to see whether the expected answers from farmers will be achieved. After administering the questionnaire, the validity has been achieved as the expected responses were in line with the expectations. From this, the questionnaire is reliable because if taken once more to the same participants, they will lead towards the same answers under similar conditions. Using the statistical tool for analysis, this questionnaire is moderately consistent at a Cronbach's alpha r = 0.409.

Data analysis

The Statistical Package for Social Sciences (SPSS) software was used for data analysis. The data was entered and cleaned. Some analytical tools were used. The mean were used to get the average age of farmers and standard deviation to measure the dispersion. The descriptive statistics were used to generate the picture of farmers and their knowledge on the use of pesticides in tomato farms. The linear regression contributed to show that the middlemen use the level of education of farmers to buy the tomato. The Bivariate correlation based on Pearson's was used to measure the association between two variables. The level of significance was tested at 95% confidence.

RESULTS AND DISCUSSION

Sociodemographic characteristics of the study

Characteristics of tomato farmers

The study done covered Mwea East and West. Out of all participants, 90% were males and 10% females. The age of interviewees was between 22 and 70 years old with an average of 42 years and a standard deviation of ±10.236. The survey reveals that, 8% of the farmers were between 18 and 28 years old, 23% between 29 and 35 years, 44% between 36 and 49 years, and 25% is for 50 years and above. Around 83% of the respondents had other business such as buying and selling rice, 14% were employed in jobs such as driving, providing casual labor and 3% had no other business.

The high involvement of males in tomato farming in this community could be linked to some factors which mostly require men in this venture. Males were mostly responding to the questionnaire (with the wife standing close to him) in most farms. Maybe, the culture of the community requires men to step forward on behalf of the family in any given occasion involving the family such as for this interview. Factually, the couples (husbands and wives) were both included in tomato farming. As rooted in African culture, females cannot take the lead of an activity when the husband is fully connected. Surely, reasons elucidating the utility of men may also engulf the needs for good organizational skills, quite number of workers, financial input and attention to details (Rutledge et al., 2015).

These results confirm studies in India by Himani et al. (2015) and in Cameroon by Tarla et al. (2015). They contrast the studies of Ayandiji and Omidiji (2011) in Nigeria who did not found a great difference (51% males versus 49% females) among gender in their survey.

Level of education: Most of the farmers had primary (38.5%) and secondary (38.5%) levels of education. 15% had tertiary, 4% university and 4% never attended any school. Most farmers from this region can read and write. This appears to be an asset for the use of pesticides in tomato farming by farmers. Easy communication can be established in both English and Kiswahili for the majority during capacity building and easy translation can be done to the lowest of non-educated farmers. For the minimum who have never attended any school, it is expected that information received by the literate on pesticide used in tomato farms can easily be transmitted to those unable to read and write. These results confirm the studies done in India by Himani et al. (2015).

Tomato pesticides management

Attitude, awareness, knowledge

The first time you heard about pesticides for protecting tomatoes in farms: Around 69% of farmers acknowledge to have seen pesticides for the first time from other farmers and 31% mentioned different sources including agrovets, agricultural expert, agricultural extension officer and during training. The sourcing for pesticides varies. The multiple source of information is a possibility for accurate, different or confusing information. The single source of information may stand as erroneous, improper and non-updated information. Farmers may be dealing among themselves either due to unavailability of agricultural extension officers (too few to serve all the farmers) as noticed in Vietnam by Huynh (2014) or because, the evidence of the good production seen from fellows' farms may influence their behavior and increase their reliability on other farmers.

Also, agricultural officers may be favoring some areas or farmers while neglecting others. Tawiah (2011) in Ghana revealed complaints that, the agricultural agents follow and advise some tomato farmers on the basis of prepaid or post-paid contracts. This practice is unfortunate as the farmers may end up spraying pesticides in farms according to inadequate information and finally produce unsafe tomato harming the health of consumers. This confirms that, the farmers are not trained at the same level and consequently do not have the same understanding of the use of pesticides. Pesticides use in tomato farms here is therefore confusing among farmers themselves. This confusion raise the necessity for the harmonization of information leading to appropriation based on the same official knowledge.

These results contradict with both the findings from Tawiah (2011) in Ghana where 48% of cultivators received their first information from other farmers and from Bandara et al. (2013) in Sri Lanka where 48.9% knew pesticides for the first time from neighbors and 51.1% got the first information from multiple sources (Extension Officers, Farmers Cooperative and Dealers). But, they confirm the results from Jamali et al. (2014) in Pakistan where 25% deal with multiple source of information.

The source from which farmers know how to use pesticides: Around 63.5% of participants said that, they learn how to use pesticides from the agrovets and 36.5% mentioned both agrovets and other farmers. The agrovets are the references for farmers and this gives them the legal authority among farmers. The extension officers and industries (which usually promote their chemicals) were ignored by the participants. This might happen because the agrovets are permanently present in the region and have proved their efficacy on pesticides use in crops. The source for the use of pesticides seems appropriate but requires clarifications on the quality of information provided by the agrovets.

The synthetic chemical shops called "agrovets" are business oriented. They may not have enough time to train or transfer information required for the best use of pesticides to the beginners in tomato farming for instance. If not reminded, agrovets may assume that, the tomato farmers buying the chemicals already have appropriate knowledge before ordering. This can be crucial as pesticides mismanagement by farmers is decried by a number of studies (Mutuku et al., 2014; Tandi et al., 2014; De Bon et al., 2015). This is delicate at the moment when chemical industries are manufacturing an endless number of pesticides for crop protection.

Assessments of pesticides use by farmers and their source differ and reveal several limits worldwide. Wasudha et al. (2015) in Surinam found for instance that, farmers knew pesticides to use in vegetable by knowledge received from parents, other farmers and pesticides shops. Such practices may either be accurate or contain missing information and gaps for the new generation of farmers. Periodic follow-up and capacities reinforcement should be inserted in strategic plans of governments. These can include information such as the last spray and withdrawal period; essential actions while spraying and after spraying; recommended pesticides to use in tomato farms; and potential health risks and exposure from misuse of pesticides in crops, environment and on farmers. Maybe, some of these points and precautions may either be known but neglected, unknown, or forgotten.

Above this, the chemical shops might not be qualified enough to provide accurate, complete and pertinent information to the farmers for the best use of pesticides in tomato farms. If trust should be on agrovets, criteria and evidence for the level of education of personnel in agrovets shops should be defined; a roadmap established and, quality assessment and audit adopted by the government. Such strategy or measures can be applied worldwide in countries with economies in transition or, in developing countries. These results are consistent with the research done by Tarla et al. (2015) in Cameroon where farmers rely on chemical vendors. Also, they confirm the work from Jamali et al. (2014) in Pakistan where 81% of farmers receive knowledge through traders.

Pesticides approval by the governmental institution Pest Control Products Board (PCPB): The farmers were asked whether they were aware of the approval of pesticides by the governmental institution Pest Control Product Board. Ninety eight percent acknowledged to be aware that the chemicals to use in the farms should be approved by the PCPB. This reveals a good sign of communication between farmers and farmers and between farmers and agrovets. It shows that, almost all farmers are using recommended agrichemicals.

The high level of regulatory requirement found in the present study is however not common. For instance, such knowledge is not the same in some sub-Saharan African countries (Tarla et al., 2015). The misappropriation of recommended pesticides by the legal authority might have led farmers in some nooks and crannies to consider pesticides as an instrument that helps to produce more tomato (May Lwin et al., 2012). It should be made clear that, pesticides are not fertilizers; they are only pests and diseases repellents or killers. Therefore, this must be considered and included as a topic during capacity building of tomato farmers. These results support the findings in Pakistan by Jamali et al. (2014). But, contradict those released by Tarla et al. (2015) in Cameroon where 69.9% of the farmers were not aware of the relevance of pesticides approval by the government and only 15% knew that they had to look at the registration number before getting pesticides needed from the agrichemicals shops.

Names of the mostly used pesticides in tomato farming: A total of 96.2% cited between two and eleven names of pesticides mostly utilized (Oshothion, Coragen, Alpha, Genomite, Dynamech, Confidor, Diacrid, Ridomil, Oshotane, Alphatox, Mistress, Milraz, Anthracol, Malathion and Karate for example) using the commercial name of the available pesticides and 3.8% were unable to cite any. These farmers know which pesticides to use when needed through a routine probably developed from their experience in tomato farming. Citing these names easily may reflect knowledge of how to use these pesticides. But still, details on some key aspects such as the safety/care in the way chemicals are used, the quality of protective clothing of farmers (rubber boots, impermeable trousers, and waterproof coverings for instance) (Matthews et al., 2003), the number of times to spray from planting to harvesting and, the withdrawal period are important. The results in the present study are in agreement with the findings of Matthews et al. (2003) in Cameroon where pesticides listed by the farmers were classified as frequently and uncommonly used.

Awareness of the usefulness of pesticides: About 98% of the respondents are aware of the importance of pesticides in tomato farms. This means, it is a common and rooted tool for tomato farming in this community. Paiboon and Tikamporn (2014) argue that, awareness is the response based on previous experience and related to the effects that happened and which lead to be conscious of the situation. It thus becomes useful to interrogate the quality of awareness claimed by farmers on the usefulness of pesticides in tomato farms.

Based on their source of information, the usefulness of pesticides in farms goes from mouth to ear and spread easily among the farmers. The information content in such a chain might decrease, be distorted, be incomplete and contain incorrect advice leading to malpractices. This may lead the farmers into wrong, inappropriate, indecent and invalid use of synthetic chemicals in tomato farms. Additionally, the relevance of the content released may depend on who shared the information, the place where it was given, the status and mood of the person at the moment of sharing. As well, the quality of content of the message received previously by the informant, the level of understanding of the listener and his/her capacity of transmitting or applying the previous information received. The reliability of the speaker as perceived by the listener also affects the effectiveness of the information received.

Regarding this, simple additional information for a better understanding and good practice of the use of pesticides is needed. These results corroborate with the finding from Surinam by Wasudha et al. (2015) who reveal that 100% of the farmers were aware of the usefulness of pesticides.

Knowledge of the use of pesticides in tomato farms: One hundred percent of the respondents acknowledged that they know how to use pesticides in tomato farms. This acknowledgement expresses doubts related to the way they usually get information on pesticides use in tomatoes farms both for the first time and in the long run. Nonetheless, studies of chemical use in tomato farms in Kenya have revealed numerous shortcomings in the practices of farmers (Nyakundi et al., 2010; Mutuku et al., 2014).

The claim of good knowledge of use of pesticides in tomato farms is questionable. Probably, a step by step procedure may reveal some flaws sustained by improper practices adopted or applied by some cultivators. This may include spray following the direction of wind, no break for cigarette smoking before ending with spray, changing cloths and washing them, taking a shower before eating and smoking; disposing empty containers of pesticides in the farms after usage and not throwing everywhere as seen in many farms, starting another task within the farms without taking a bath and changing the cloths (Paiboon and Tikamporn, 2014). These results contradict those from Pakistan by Jamali et al. (2014) who found many irregularities on the practices of the farmers in the use of pesticides in vegetables.

Knowledge of the names of pesticides used in tomatoes' farms (The farmers' realism): Results show that, 56% of the participants ask other farmers and 44% get the names from agrovets, agricultural extension officers and the agricultural chemical company. A large number of farmers purchase their pesticides based on concrete evidence in tomato farms. Probably, they witness the status of the produces in farms before asking the names. This shows the realism of farmers. Although it seems logical for the farmers to do so, this result may also be explained by the inability for some farmers to read properly the labels on the containers of pesticides or, their incapacity to remember the names of the pesticides due to illiteracy (Nyirenda et al., 2011; Tarla et al., 2015).

Relying on other farmers may show that, there is no constant chemical pesticide regularly used in the area. Probably, pests and diseases are either dynamic or, they are now resistant to pesticides. Nonetheless, attention should be paid as 67.3% of the farmers affirm that the agrovets always promote new powerful chemical products. A minority of the farmers got the names of pesticides from those accredited to provide the information (that is the right source including agrovets and agriculture extension). The farmers are most likely to rely on each other based on the success or the best yields witnessed in the neighboring farms as also shown in India by Himani et al. (2015). They learn how others have overcome some difficulties so as to harvest good tomatoes. This reveals the realism of the tomato farmers. Before ordering for a pesticide, the farmers have the reason and expected outcomes from the brand ordered. The results in the present study support both the finding from Jamali et al. (2014) who reminded that, the knowledge for chemicals spray in farms has a variety of origins and Tarla et al. (2015) who stated that farmers order their chemicals through advices from other farmers, suppliers and agricultural extension agent.

Knowledge and culture (An index to clarify for the 7 days of pre-harvest interval): Data reveals that 84.8% wait before harvesting after application of pesticide because it is the culture in the community, 6.5% say it depends of the days of the markets, 4.3% follow the instruction from the manufacturers, 2.2% used to be reminded by the agricultural extension officers and 2.2% do not know (Figure 1).

The farmers have insufficient knowledge. They should move from blind habit of culture to real understanding of pesticide practices and reality in the field. Insects' resistance to pesticides is currently decried (İnci and Ikten, 2017). In spite of this, farmers of this community are still stuck to culture which does not follow the dynamism of insects' pest depicted as more and more resistant to synthetic chemicals. This trend might lead into pesticides resistance and their misuse causing tomato contamination and health risk exposure. The farmers of this community seem not to be aware of the potential health's exposure for those consuming tomato contaminated with chemical residues above the maximum limits. Majority are followers of culture of tomato farming in the area. They have no idea on pesticide residues in post-harvest tomatoes and its effect on the health of consumers (Shashi et al., 2016). They apply pesticides and wait because they found it rooted in the community. Culture being the product between man and environment, farmers are just the followers of practices and do not have accurate knowledge. The pre-harvest interval here is not a precaution for the production of safe vegetable for human consumption. If the farmers' knowledge is uplifted, almost all the farmers will follow the rules. These findings are in agreement with those of Wasudha et al. (2015). They found that 100% of farmers in Surinam know the pre-harvest time through parents' experience and culture.

Famers' pesticides practices

Number of Years farmers have used pesticides in tomato farms: Sixty four percent of the farmers have more than 6 years in tomato farming, 16% have between 5 and 6 years, 6% has 3 to 4 years, while 14% have only 2 years. Tomato farming has been embraced by the community for quite some time. As such, practices as pesticides use in farms may have become a routine for most of these farmers. Despite this, a dual situation for this category is envisaged: on one hand, the large number of this group seems an asset for use of pesticides in tomato farming. On the other hand, this set can be a source for malpractices in case they did not have appropriate skills for pesticides management. They may have transferred incomplete or improper knowledge to the young generation and the socioeconomic fallouts will still be harmful for families and society as depicted by Huynh (2014). The necessity to understand the level of pesticides attained by the elders is relevant. Most of them may have worked for years, but their management of pesticides remains weak or shows gaps that may need capacity building.

Again, the source where they learned about the use of pesticides is crucial; this might unveil or give an idea of their real use of pesticides in farms. In spite of their long experience, capacity building for update and reconstitutions of the knowledge on pesticides use can be organized by the government and other stakeholders not only in Kenya, but everywhere such results are depicted. These results are consistent with those from Wasuhda et al. (2015) in Surinam where most respondents (66.7%) and Mispan et al. (2015) from Malaysia where majority of the farmers (60%) have a lot of experience in tomato farming and use of pesticides.

Periodicity for pesticides spray in the tomato farms: Analysis indicates that 93.9% of the farmers spray pesticides every week in tomato farms, 4.1% spray twice a month and 2% spray as they feel they have to protect the vegetable. A good percentage of farmers (93.9%)

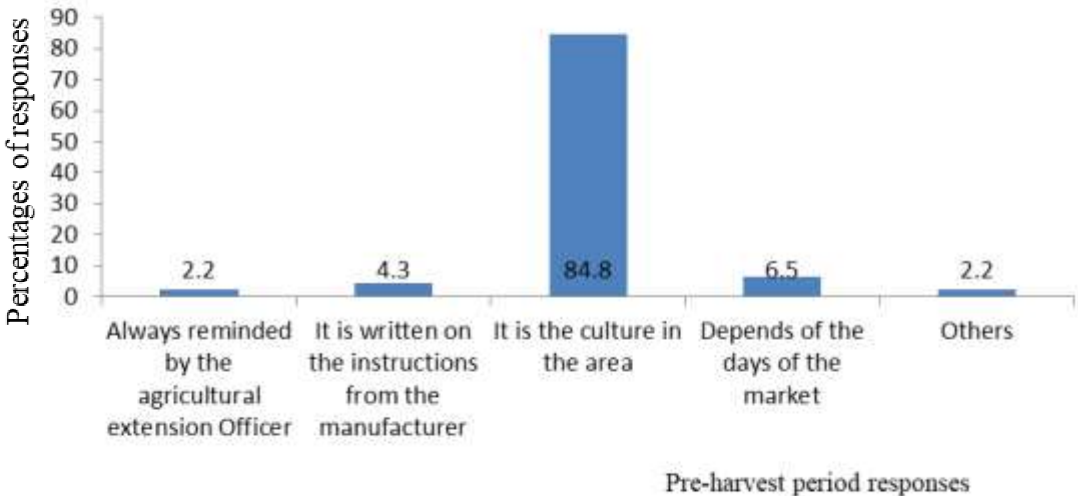

Figure 1. Justification for observing the pre-harvest period.

follow the same rule of spraying pesticides every week in farms. A routine has been established in the application of the chemicals in this community. This expresses a commune alignment toward the same action within the area. Although high proportion follows the same rule, the minority may have developed unsafe thoughts on the meaning of pesticides and its role in farms. For instance, 2% think synthetic chemicals spray is important for good yields and returns. The latter minority may also believe in addition that, the quantity of pesticides wrap in the containers is not enough to cover the surface of the farms for pests and diseases control (Shashi et al., 2016).

Institutions in charge of national approval of chemicals in developing countries should be equipped with laboratories for quality control of the chemicals before recommendation. These results agree with those from Mutuku et al. (2014) in Kaliluni-Kenya where 86.1% spray weekly, Lutap and Atis (2013) in Ilocos-Philippines with 90% of weekly application, and in India by Shashi et al. (2016) who found that 60% of farmers spray pesticides in a weekly basis in their farms. But, they contrast with those from Wasudha et al. (2015) in Surinam where 50% of farmers spray pesticides twice per day- early in the morning and late in the afternoon.

Quality of social interaction between farmers and the approximate last day or time for spraying pesticides on the tomato farm: Approximately, 76.9% of the farmers have at least seven days for pre-harvest period; 7.7% harvest 14 days after the last spray, 7.7% harvest four days after, 5.8% do harvest between 2 to 6 days from the final chemical protection and 1.9% follow instructions from the manufacturers (Figure 2). Six different answers were obtained from the participants. The disparity and inaccuracy for the pre-harvest period remains a challenge in this community. Farmers have limited awareness of pesticides residues effect and the appropriate pre-harvest period which results in exposure and potential health risk consequences on human, fauna and environment.

These answers raise doubt on the quality of the source of pesticides held by farmers and their awareness for the usefulness and good management. With no certainties for the knowledge received from agrovets and other farmers, the understanding of pesticides in this community remains precarious. There is a set of social knowledge that should be assessed from the farmers. They should reveal the place where they received the information, the mood of the fellow who delivered the knowledge and the quality of their relationship. These characteristics are useful social determinants that may influence the quality of knowledge transmitted from a farmer to another. A qualitative survey can be developed and tested in areas around the world. The aim is to find the trends and potential outcomes which might lead to a policy design for pesticides training or capacity reinforcement of the tomato farms.

These results are consistent with those reported by Himani et al. (2015) in India. They found that, 16% of farmers spray pesticides even during harvest and 37% leave a pre-harvest interval of 11 to 14 days. They also corroborate with those of Shashi et al. (2016) where 86% of farmers in open field wait for two days, whereas 71.42% of farmers in poly house allow a moment of seven days for the pre-harvest time. They contrast with the results from Ghana by Dankwah (2014) where 60% of farmers wait for 11 to 14 days and 30% allow a pre-harvest interval from 7 to 10 days.

Pesticides spray in post-harvest period: Although 94% do not spray pesticides after harvesting the tomato, 6% continue with post-harvest spray of pesticides to protect

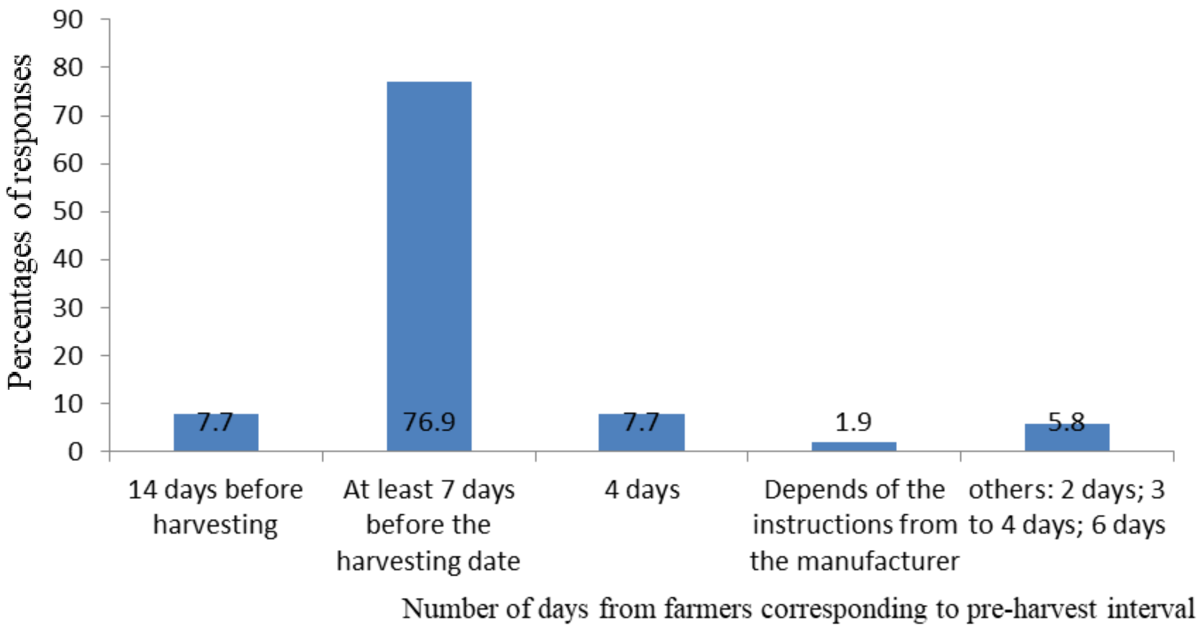

Figure 2. Pre-harvest interval after the last spray of pesticides in farms.

the produce. This may be explained by the need for making a good deal with the middlemen and the fear of postharvest diseases (*alternaria*, *buckeye rot*, *gray mold*, *soft rot*, *sour rot* and *bacterial soft rot*) attacking the crops (Rutledge, 2015). Other reasons may include: difficult access to the markets and worries of returns on investment to meet the financial households' needs. Postharvest spray of pesticides on tomato also signifies insufficient knowledge of the farmers. They ought to use chlorine gas, thiabendazole, calcium hypochlorite, calcium chloride ($CaCl_2$), 1-methylcyclopropene (1-MCP) and sodium hypochlorite (Arah et al., 2016; Rutledge, 2015). This result confirms the finding in India by Himani et al. (2015) revealing that 16% of the farmers do spray pesticides on tomato after harvesting.

Level of education, preference of middlemen and farm size as determinants of pesticides management in tomato farms

The level of education plays a great role in tomato farming and the middlemen are the assessors determining the welfare of the tomato farmers in the farming areas. The regression analysis between the independent variable (preferences of the middlemen) and the dependent variable (level of education) when tested is at 0.05 significant. The model statistically tested at 95% level is significant (p= 0.0015). It can then be said with confidence that, the preference of the middlemen depends on the level of education of the farmers

There is a strong correlation between the annual income and the farm size (r= 0.51) in which the middlemen still play a key role by determining the variety of tomato they prefer at post-harvest. It can confidently be asserted that, the regression explains the independent variable (farm size) on the variability of the dependent variable (annual income). This may show that, more investment in tomato farming may lead to more benefits. This can then be related to the intensive use of pesticides for the return on investment as the middlemen are unpredictable on their choice. This may lead to the misuse of pesticides if farmers do not have good knowledge on potential repercussions on consumers at post-harvest. The Pearson's correlation coefficient applied to income and farm size discloses a strong positive association at r= 0.71. This shows that, the farmers may likely misuse the chemicals if they are not fully aware of their negative aspects in post-harvest. This trend reveals the influence of poverty on the use of pesticides in tomato farms.

Conclusion

This study has reviewed some key points able to come with an appraisal on the use and knowledge of pesticides in the tomato farming community Mwea. The current results disclose gaps in understanding the use of pesticides in tomato's farms. Farmers are convinced of their good practices, whereas lots are still to do. For a community rank among the top four of the highest producers of tomatoes in Kenya, capacity building is needed. Of course, the community is doing so well, the farmers are able to transfer skills on pesticides use and a strong collaboration does exist among them. This is why more efforts from the government and the international community should be added in order to meet the standards of chemical use in tomato farms and the quality requirements of the markets for tomato. Under this scheme, the burden of diseases will decrease in households and governments and a sustainable development will rise with healthy people consuming safe tomatoes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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