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Knowledge of vegetable insect pests, diseases and control measures in Morogoro and Iringa regions in Tanzania: A call for integrated pest management

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This study investigates vegetable growers' knowledge about insect pests, diseases and control methods. The study adopted cross-sectional research design, employing survey method and involving 400 randomly selected vegetable growers. Statistical Package for the Social Sciences (SPSS) was used to summarize raw data. Colored cards of important pests coupled with field visits were used for pest identification. The results show that 87.1% of the tomato growers reported tomato leaf miner (*Tuta absoluta*) as one of the important insect pests. Cucurbit growers reported mainly cucumber beetle (*Diabrotica undecimpunctata*) and cucumber moth (*Diaphania indica*). Cabbage and onion growers reported cabbage aphids (*Brevicoryne brassicae*) and onion thrips (*Thrips tabaci*), respectively. Diseases reported were mainly early (*Alternaria solani*) and late (*Phytophthora infestans*) blights in tomato and onion respectively, purple blotch in onion, cucumber blight in cucurbits and cabbage blight in cabbages. Insect pest and diseases control was mainly through synthetic pesticides. Frequency of spray was highest in tomato and cucurbits followed by onion. However, the knowledge on tank mixing, record keeping and Integrated Pest Management was limited. It is critical to have a common understanding about insect pests, diseases and control methods that are environmental friendly. Therefore, farmers should be trained on different issues regarding vegetable production and safe use of pesticides. The key training areas should include tank mixing, pest identification and thresholds, and record keeping.

Key words: Control methods, diseases, Integrated Pest Management (IPM), vegetable pests.

INTRODUCTION

Vegetables are important components of daily diets and sources of income in rural, urban and peri-urban areas in

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Africa (James et al., 2010). Literature shows that vegetables are critical sources of macro and micronutrients that provide vitamins and minerals (Marles, 2017). They also provide farmers with higher income per hectare than cereal, root, and tuber crops (Abanga et al., 2014), and its production is a year round activity in the tropical region. Thus, vegetables are potential for smoothening and moving vegetable growers out of income poverty. Sub-Saharan Africa (SSA) is characterized by malnutrition and stunting problems particularly among under-five children. For example, in a country like Tanzania, vitamin A deficiency affects 33% of all children and 37% of all women (Lotter et al., 2014). To that effect, if vegetable production, productivity and consumption are increased, it can improve human health, which in turn improves livelihoods thereby transforming standards of living among vegetable growers and the entire population at large in the country.

A study conducted by Lotter et al. (2014) in Tanzania in the regions of Dodoma, Arusha, Morogoro, and Iringa, which involved 160 vegetable traders and producers reports at least 275 plant species in Africa are used as vegetables both indigenous and exotic ones. Some of the important vegetables in Morogoro and Iringa, where the current study was conducted, include tomato, onion, cucurbits and cabbage. Tropical conditions in Africa provide favourable climate for vegetable production. However, one of the challenges affecting the sub-sector is high insect pests and disease incidence. For instance, USAID (2009) identified a number of pests affecting vegetables in Tanzania. The same study shows that tomato is affected mainly by insects like American bollworms (*Helicoverpa armigera*), root knot nematodes (*Meloidogyne* species), and red spider mites (*Tetranicus urticae*), while diseases include late blight (*Phytophthora infestans*). Onion pests include onion thrips (*Thrips tabaci*), while diseases include downy mildew (*Peronospora destructor*), purple blotch (*Alternaria porri*) and storage rots (USAID, 2009). Although cabbage has few major pest problems, it is mainly affected by diamond black moth (*Plutella xylostella*) while the common disease affecting the crop is black rot (*Xanthomonas campestris* pv. *campestris*) that can reduce yield up to 90% during rainy season (USAID, 2009).

Pests cause economic loss by increasing cost of production to the farmers. They also cause human illness, and environmental problems due to acute poisoning and seepage of pesticide residues to water sources (Mdegela et al., 2013; Karianthi et al., 2017). According to USAID (2009), pests account for 25 to 50% of crop losses worldwide while application of synthetic chemicals is the main method of pest control. According to Abanga et al. (2014), almost 92% of farmers in tropical conditions use synthetic pesticides to control pests in vegetables. However, farmers do not determine correctly when to spray their vegetables resulting into routine sprays leading to unnecessary high frequency of pesticide application. This situation increases cost of production, contaminate the environment, and disturb the ecosystem by killing beneficial insects (Kihampa et al., 2020).

Literature uncovers different methods of pest control including cultural, physical, mechanical, biological and chemical (Abanga et al., 2014; James et al., 2010). While other methods are environmental friendly, chemical control kills not only the insect pests but also beneficial insects. They also cause toxicity to the vegetables and the environment, and therefore affect living of other organisms including humans. Because of frequent application and/or unacceptable combination of pesticides, pests have developed resistance against them. At least 504 species of insects have developed resistance to at least one pesticide (USAID, 2009). Thus, there is resurgence of pests, pesticide residues, killing of beneficial insects, and environmental pollution in some areas in SSA including Tanzania (Huis, 2009).

Integrated Pest Management (IPM) is a farmer-based and knowledge-intensive management approach, critical to encouraging natural and cultural control of pest populations by anticipating pest problems and managing their numbers to reduce losses. This uses multiple tactics including biological control, habitat manipulation, soil health management, use of resistant varieties, and modification of cultural practices. It has emerged in order to avoid problems of overusing pesticides especially those with concern to human health and the environment (Huis, 2009). This study was conducted to evaluate the knowledge of vegetable growers on insect pests, diseases and their control measures in Morogoro and Iringa regions in Tanzania.

METHODOLOGY

The study was conducted in five districts: Morogoro, Kilosa and Mvomero in Morogoro region, and Kilolo and Iringa districts in Iringa region. The villages involved in each district are as shown in Figure 1. Data collection took place between December 2016 and January 2017. The study adopted descriptive cross-sectional research design to explain the relationship between variables.

Smallholder men and women vegetable growers in 15 villages were involved (Figure 1). At a district level, staff based in the District Agriculture and Irrigation Cooperative Office (DAICO) were involved in selection of the villages considered potential for vegetable production mainly tomatoes, onions, cabbage and cucurbits. In order to determine the sample size in each district and village, a list of all vegetable growers was prepared with the help of village and ward extension officers. Based on the pre-determined sample size in each region, a proportion sampling was used to establish sample size shown in Table 1. The total sample size for the two regions was 400. The formula used to determine sample size in a village or district is shown as:

$$n_i = n*p_i$$

where n_i is the sample size in a village or district, n is the total number of vegetable growers in a village or district and p_i is the proportion of vegetable growers in a village or district.

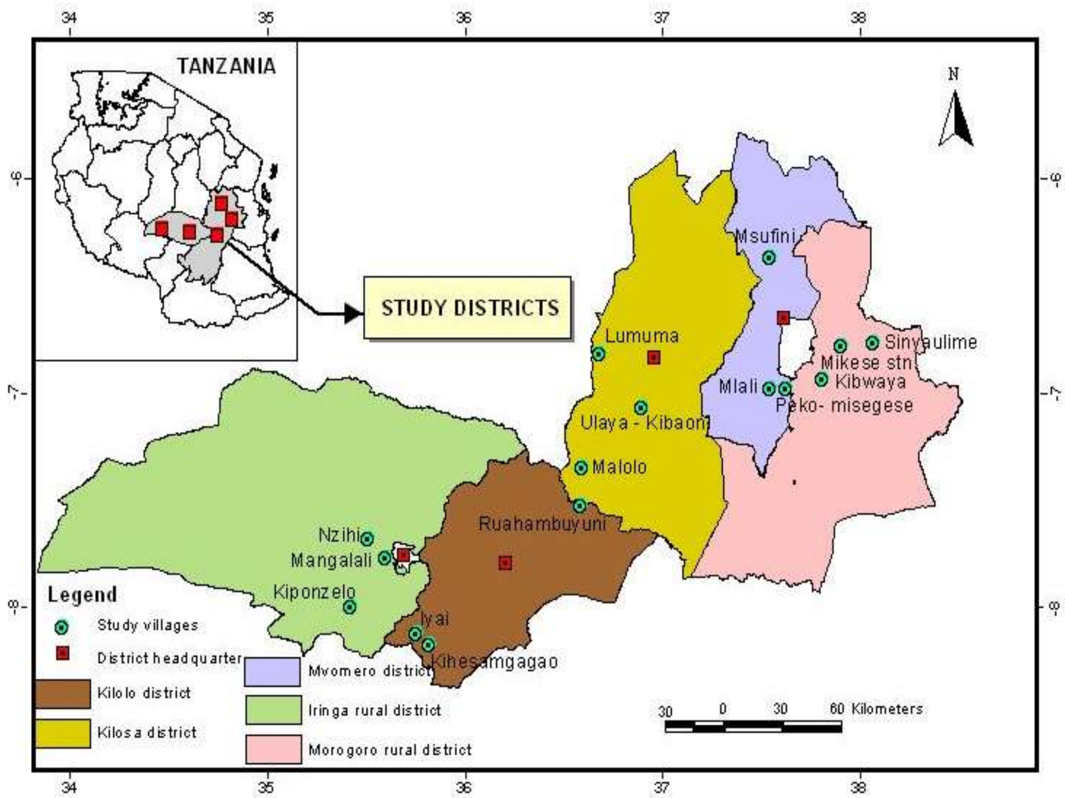

Figure 1. Map showing study districts and villages

Table 1. Vegetable growers sampled.

District	Number of vegetable growers	Proportion	Sample size per district
Mvomero	325	0.39	78
Kilosa	366	0.44	88
Morogoro rural	144	0.17	34
Total	835	1.00	200
Kilolo	475	0.56	111
Iringa Rural	379	0.44	89
Total	854	1.00	200
Total Sample			400

The proportion of vegetable growers (Pi) was computed by taking the total number of vegetable growers in a village or district divided by total number of vegetable growers in all villages selected in a district or total number of vegetable growers in all districts selected in a region, respectively. A sampling frame of vegetable growers was prepared for each village. Individual vegetable growers were selected using systematic random sampling from a sampling frame.

Data were collected using a structured questionnaire with closed and open-ended questions. Coloured picture cards of important pests coupled with field visits were used for pest identification. Data were cleaned, verified, coded and analyzed using Statistical Package for Social Sciences (SPSS) and descriptive statistics mainly, means, percentages and cross tabulations were computed.

RESULTS

Socio-economic and demographic characteristics of the respondents

Table 2 presents characteristics of the respondents. Overall, 73.3% of the respondents were male. The highest percent of male was reported amongst cucurbits growers followed by cabbage growers. However, there were few cucurbits and cabbage growers, compared to tomato and onion in the sample and therefore it is difficult

Table 2. Respondents' socio-economic and demographic characteristics by type of vegetables farmed.

Sex	Tomato growers (n=205)	Onion growers (n=141)	Cabbage growers (n=45)	Cucurbits growers (n=9)	Total (400)
Female	23.0	36.2	20.0	0.0	26.7
Male	77.0	63.8	80.0	100.0	73.3
			χ^2 = 12.251; df = 3; P = 0.007		

		Respondents' highest education level in percentages			
Education level	**Tomatoes (n=205)**	**Onion (n=141)**	**Cabbages (n=45)**	**Cucurbits (n=9)**	**Total (400)**
None	5.7	5.7	6.7	0.0	5.7
Primary (P1-P7)	76.6	79.4	84.4	77.8	78.5
Secondary (F1-F4)	16.3	13.5	8.9	22.2	14.6
Secondary (F5-F6)	0.5	0.7	0.0	0.0	0.5
Technical/College	1.0	0.0	0.0	0.0	0.5
University	0.0	0.7	0.0	0.0	0.2

		Membership in farmer organizations in percentages			
Response	**Tomatoes (n=205)**	**Onion (n=141)**	**Cabbages (n=45)**	**Cucurbits (n=9)**	**Total (400)**
No	78.0	56.0	60.0	66.7	68.1
Yes	22.0	44.0	40.0	33.3	31.9
			χ^2 = 20.226; df = 3; P = 0.000		

to generalize whether cucurbits and cabbages were largely grown by male in the districts. Table 2 also shows that 78.5% of the respondents completed primary education as their highest education level. The rest held either an ordinary level of secondary education or higher education levels. This is a common trend in most of the rural areas of Tanzania (URT, 2016). Overall, 81.7% of the population in Tanzania completed primary education (URT, 2014).

Education is one of the means to achieving sustainable livelihood security through sustainable use of improved technologies and innovations. This implies that education is a necessary ingredient for achieving development in general through increasing agricultural productivity. However, access to education at all levels in Tanzania is higher among men relative to women because of women subordination and discrimination at a household, community and societal level. The proportion of educated women decreases from lower to higher levels of education in the country (Meena, 1996).

The results also show that 31.9% of the respondents were members in farmer organizations implying that majority were not members in any farmer organization (Table 2).

Age, household size and distance from households to a nearest town are shown in Table 3. Overall, the mean age of vegetable growers was 40 years. There were some variations in terms of age between different vegetable crops. Cabbage (41.6 years) and tomato (41.3 years) growers were generally older than growers of the other crops. Considering the overall minimum age that was 19 years, maximum age that was 72 years and an overall standard deviation which was almost 11 years, it is clear that the vegetable growers' age was spread out from the mean. This implies that vegetable farming provided employment to the youth and older farmers as well. The number of household members showed an average of 5.2 persons with a standard deviation of 2.4 (Table 3). Data at a national level give a mean of 4.7 persons (URT, 2014). This suggests that the household size among vegetable growers was higher than the national average. Bigger households tend to be poorer than small ones in the country and elsewhere in the world (URT, 2014). The mean distance from home to a nearest town was 25.1 km with a standard deviation of 25.8. This implies that while some households were far from town, others were close to town areas. Being close to town areas is an opportunity for access to market and agricultural inputs from agro-dealers at relatively low cost.

Knowledge of pests and pest management

The results show that the most important insect pest of tomato was tomato leaf miner (*Tuta absoluta*) reported by 87.1% of the respondents followed by aphids (*Aphis gossypii*) (Figure 2). Other pests include red spider mites (*T. urticae*), American bollworm (*H. armigera*), whiteflies (*Bemisia tabaci)* and cutworms (*Agrotis* species).

On pest control, all tomato growers used synthetic insecticides to control insect pests. There were 13 most common active ingredients (Figure 3). Most insecticides

Table 3. Respondents' age, household size and distance of a household to a nearest town.

Variable	Mean	Count	Std. Deviation	Minimum	Maximum
Tomato growers	39.0	209	11.3	19.0	70.0
Onion growers	41.3	141	10.9	20.0	72.0
Cabbage growers	41.6	45	12.5	21.0	70.0
Cucurbits growers	34.2	9	7.6	24.0	46.0
Total	40.0	404	11.3	19.0	72.0
	Total number of household members including the respondent				
	Mean	**Count**	**Std. Deviation**	**Minimum**	**Maximum**
Tomato growers	5.1	209	2.3	1.0	17.0
Onion growers	5.1	141	2.1	1.0	13.0
Cabbage growers	5.7	45	3.6	1.0	21.0
Cucurbits growers	4.4	9	1.8	1.0	7.0
Total	5.2	404	2.4	1.0	21.0
	Distance (km) from household to a nearest town				
	Mean	**Count**	**Std. Deviation**	**Minimum**	**Maximum**
Tomato growers	22.3	173	20.3	0.0	107.0
Onion growers	28.3	89	33.7	0.3	130.0
Cabbage growers	36.7	25	23.7	1.0	72.0
Cucurbits growers	16.1	9	24.2	0.5	60.0
Total	25.1	296	25.8	0.0	130.0

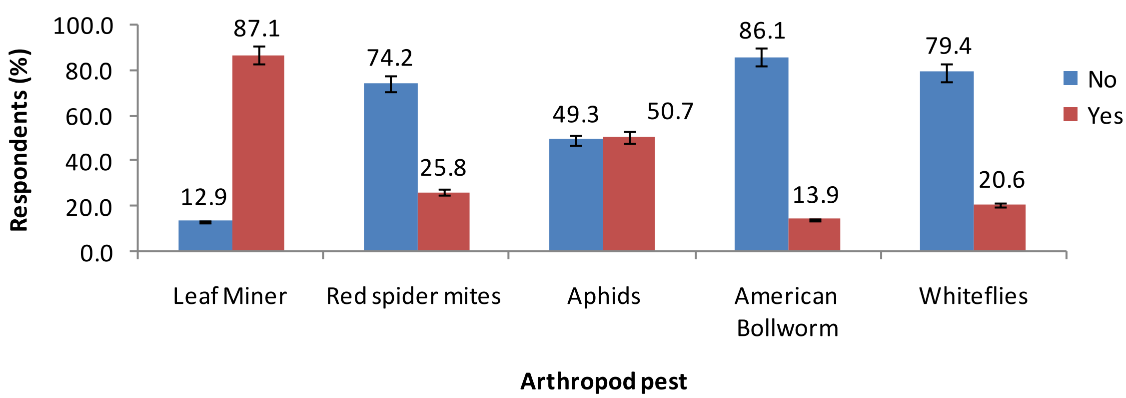

Figure 2. Most important arthropod pests of tomato.

come with different trade names but with the same active ingredient.

Cucurbits were attacked by a narrower range of insect pests. The most common ones were cucumber beetle (*Diabrotica undecimpunctata*) and cucumber moth (*Diaphania indica*) reported by 33.3% each. Others were cucumber fruit worm (*Diaphania nitidalis*), grasshopper (*Melaloplus differentialis*), thrips (*Frankliniella occidentalis*) and aphids (*A. gossypii*) (Figure 4). The number of cucurbit growers reported insect pests were less than those who did not report pests. This corresponds to fewer insecticide formulations that were used in their control compared to those used for insect pest control in tomato. Cucurbits growers also used insecticides as a sole control measure against insect pests. However, the range of insecticides used was narrow. The most common insecticides were Attakan (Imidacloprid), Actelic (Pirimiphos-Methyl), Duduba (Cypermethrin + Chlorpyrifos) and Thionex (Endosulfan).

Cabbage was grown in cool climates in the highlands in Kilolo district. The crop is susceptible to a variety of arthropod pests. About 67% of the respondents reported

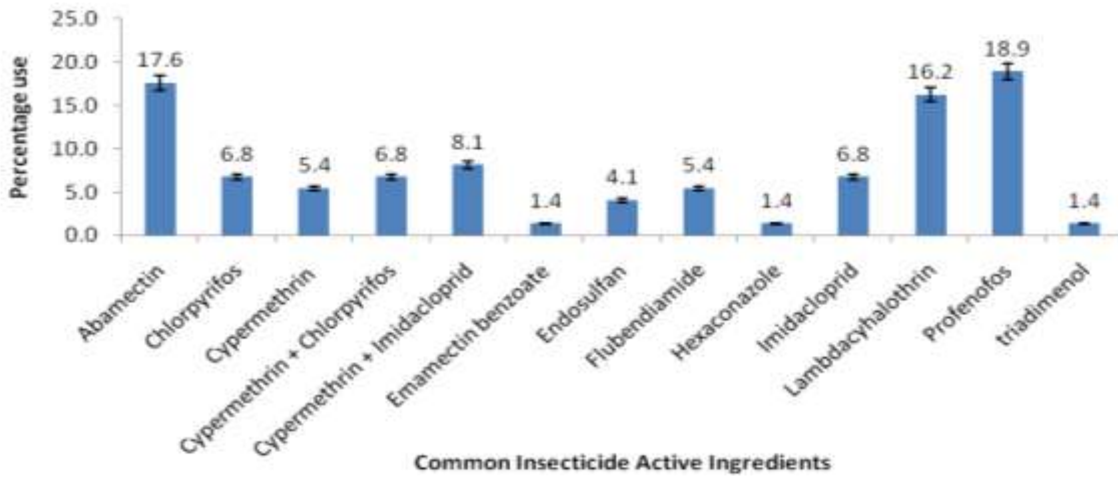

Figure 3. Common insecticide active ingredients used.

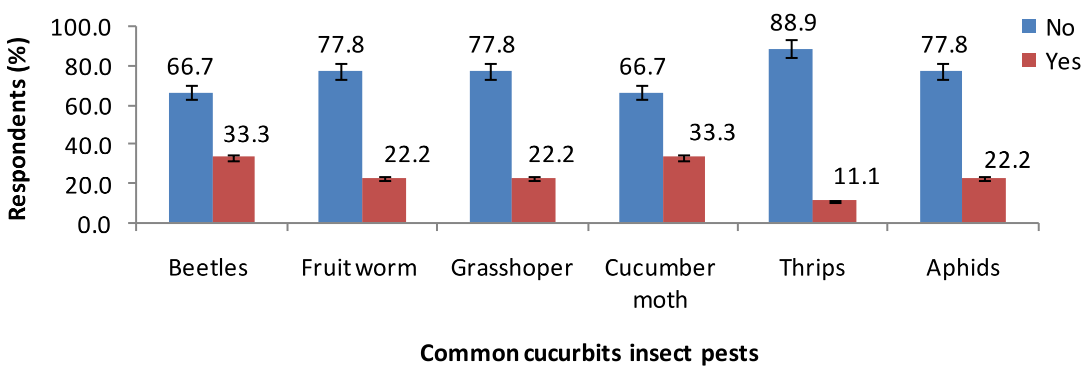

Figure 4. Most important cucurbit insect pests.

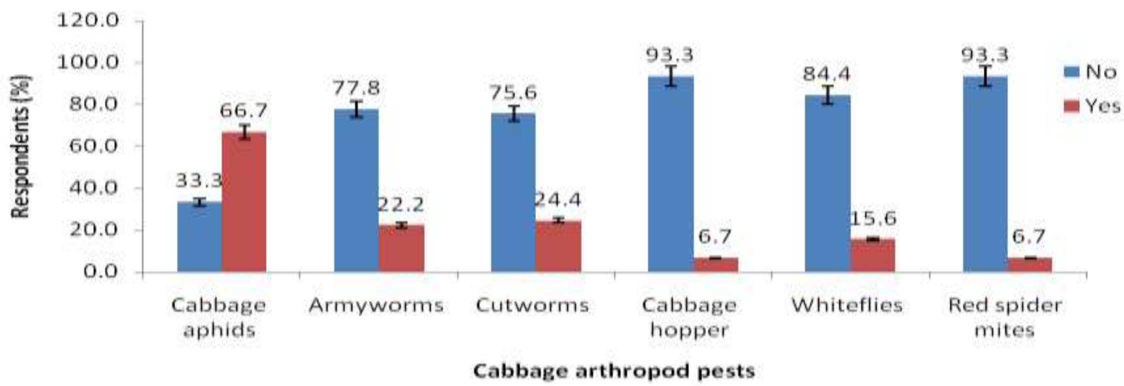

Figure 5. Most important cabbage arthropod pests.

that the most important insect pest of cabbage was cabbage aphids (*Brevicoryne brassicae*). These were the most destructive insect pests followed by cutworms (*Agrotis* spp.). Other insect pests reported were army worms (*Spodoptera exempta*), cabbage hopper (*Graphocephala coccinea*), red spider mites (*T. urticae*) and white flies (*B. tabaci*) (Figure 5).

The results also show that all cabbage growers controlled arthropod pest by using chemical insecticides. This implies that farmers lacked alternative control measures. The commonly used insecticides in the control of arthropod pests on cabbage are presented in Table 4.

Table 4. Common cabbage arthropod pests and insecticides used for their control.

Insect local name	Insect pest English and scientific names	Insecticide trade name	Insecticide active ingredient
Udaka/ Wadudu mafuta	Cabbage Aphids (*Brevicoryne brassicae*)	Vigmax	Foliar fertilizer. Not an insecticide but was reported by the farmers
		Ninja	Lambdacyhalothrin
		Thionex	Endosulfan
		Xantho	Hexaconazole
		Dursban	Chlorpyrifos
		Karate	Lambdacyhalothrin
		Thiodan	Azoxystrobin
		Hexando	-
		Duduba	Cypermethrin + Chlorpyrifos
		Selecron	Profenofos
Viwavi	Army worms (*Spodoptera exempta*)	Furadan	Carbofuran
		Karate	Lambdacyhalothrin
		Thiodan	Azoxystrobin
Vikatashina	Cutworms (*Agrotis* spp.)	Thionex	Endosulfan
		Karate	Lambdacyhalothrin
Panzi	Cabbage hopper (*Graphocephala coccinea*)	Thiodan	Azoxystrobin
Utitiri	Red spider mites (*Tetranicus urticae*)	Duduba	Cypermethrin + Chlorpyrifos
Vithiripi	Thrips (*Thrips tabaci*)	Selecron	Profenofos
Vipepeo weupe	White flies (*Bemisia tabaci)*	Vertigo	Abamectin
		Selecron	Profenofos
		Thionex	Endosulfan

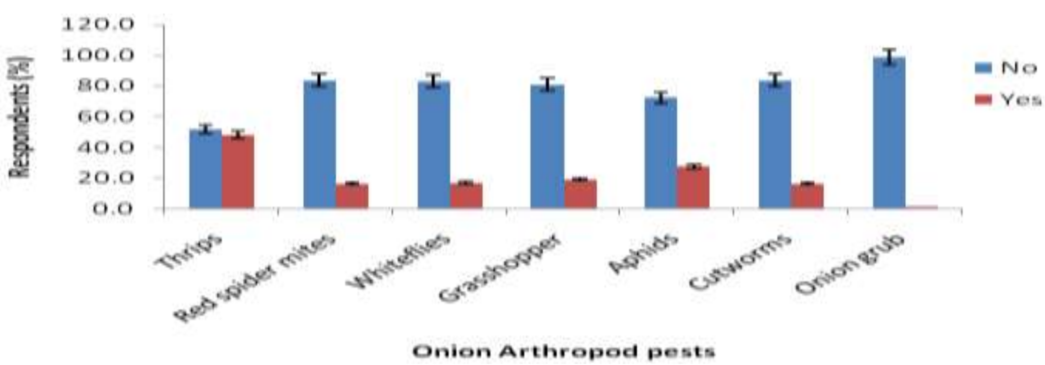

Figure 6. Common arthropod pests of onion.

Onion is also attacked by a variety of insect pests. Nearly 48% of the respondents mentioned onion thrips (*Thrips tabaci*) as the most important insect pest followed by aphids (*A. gossypii*) (Figure 6). On the other hand, onion thrips injury was mentioned by farmers as a disease by naming it as “onion blight disease” and was reported by 44% (n=141) as one of the most important “disease”. These are most problematic pests during warm and dry conditions. The most effective chemical control of onion thrips includes profenophos and neem oil (Das et al.,

Table 5. Respondents' responses on beneficial insects in percentages.

Insect	Tomato (n=205)		Cucurbits (n=9)		Cabbage (n=45)		Onion (n=141)	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Spider	5	38.5	0	0.0	0	0.0	0	0.0
Red ant	6	46.2	1	50.0	8	88.9	0	0.0
Black ant	0	0.0	1	50.0	1	11.1	0	0.0
Birds	1	7.7	0	0.0	0	0.0	0	0.0
Frog	1	7.7	0	0.0	0	0.0	0	0.0
Total	13	100.0	2	100.0	9	100.0	0	0.0

Table 6. Number of times a farmer sprayed pesticides in vegetables in the previous season

Number	Tomatoes (n=205)	Cucurbits (n=9)	Cabbage (n=45)	Onion (n=141)
Didn't spray at all	1.0	0.0	0.0	0.0
Sprayed once	1.0	0.0	0.0	2.8
Sprayed twice	0.0	0.0	28.9	19.1
Sprayed three times	9.1	22.2	42.2	17.0
Sprayed four to five times	24.9	11.1	20.0	16.3
Sprayed six to ten times	22.5	22.2	2.2	34.0
Sprayed more than ten times	41.6	44.4	6.7	10.6

Table 7. Respondents' responses about meaning of IPM in percentages.

Understanding of IPM	Tomatoes (n=205)	Cucurbits (n=9)	Cabbage (n=45)	Onion (n=141)
Reduced pesticide use	4.8	0.0	0.0	2.1
Any other means to control pests besides chemicals	4.3	0.0	2.2	7.8
Preserving natural enemies	1.4	0.0	0.0	0.0
Use of multiple tactics	1.0	0.0	0.0	0.7
None	88.5	100.0	97.8	89.4

2017).

Beneficial insects

Not all insects are destructive, some are beneficial to vegetables, and this helps to balance the ecosystem. Respondents were asked to mention beneficial insects. The results show that about 46% of the tomato growers reported red ant and 38.5% reported spider as beneficial insects which they knew (Table 5). In addition, 50% of cucurbit growers reported red and black ants, while 88.9% of the cabbage growers reported red ant. Onion growers did not report any beneficial insect suggesting limited knowledge on this aspect.

Frequency of spraying synthetic insecticides

The frequency to which vegetable growers sprayed their crops with pesticides is shown in Table 6. Generally, the spraying frequencies per cropping season were variable across crops. In tomato for example, 47.4% of the respondents sprayed five to ten times while 41.6% sprayed more than ten times. For cucurbits, about 44.4% of the growers sprayed more than ten times and for onion, about 60.9% of the growers reported spraying 5 to more than 10 times per cropping season. Cabbage was the only crop with the lowest frequencies of spraying, where 62.2% of the growers sprayed three to five times per cropping season.

Integrated pest management

Table 7 shows respondents' responses about the knowledge of Integrated Pest Management (IPM). All cucurbits growers were not aware whatsoever about the meaning of IPM. In addition, 97.8% of the cabbage growers, 89.4% of the onion growers and 88.5% of the

Table 8. Categories of IPM knowledge by respondents' sex.

Category	Tomato		Cucurbits		Cabbage		Onion	
	Female (n=48)	Male (n=157)	Female (n=0)	Male (n=9)	Female (n=9)	Male (n=36)	Female (n=51)	Male (n=90)
No Idea about IPM	20.9	79.1	0.0	100.0	20.5	79.5	38.9	61.1
Sketchy idea about IPM	30.4	69.6	0.0	0.0	0.0	100.0	13.3	86.7
Basic idea about IPM	75.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	23.0	77.0	0.0	100.0	20.0	80.0	36.2	63.8
	χ^2 = 7.29; df =2; P = 0.026		-		χ^2 = 0.23; df =1; P = 0.613		χ^2 = 3.80; df =1; P = 0.052	

Table 9. Methods used to control insect pests and diseases apart from pesticides.

Methods	Count	Percent
Tomato		
Various local botanicals	26	62
Mixed farming	6	14.3
Weeding	9	21.4
Ashes	4	9.5
Mosquito net	1	2.4
Uproot the affected plants	2	4.8
Total	48	114.3
Onion		
Using boarder plants	4	28.6
Weeding to remove alternative hosts	2	14.3
Crop rotation	3	21.4
Juice extracted from neem tree leaves	3	21.4
Peppers	4	28.6
Field sanitation	2	14.3
Trap crops	2	14.3
Total	20	142.9

The total percent exceeds 100 because of multiple responses.

tomato growers similarly had no knowledge about IPM. Based on gender, female tomato growers had basic ideas relative to male tomato growers and this difference was significant at 5% level of significance (Table 8).

The results presented in Table 9 show that a few tomato and onion growers reported alternative methods of controlling pests apart from using pesticides. Specifically, 62% of the tomato growers reported use of various local botanicals including neem (*Azadirachta indica*) extract followed by 21.4% who reported weeding. For the case of onion, nearly 29% of the growers reported use of boarder plants or hot pepper while 21.4% reported use of crop rotation or neem. This implies that they were knowledgeable about alternative control methods though did not apply the methods. Cucurbits and cabbage growers did not report an alternative control method apart from pesticides indicating that they were not knowledgeable.

Diseases

Tomato blights: early blight (*Alternaria solani*) and late blight (*P. infestans*) were the most frequently reported (49.3%, n=209) tomato diseases. This was followed by tomato leaf mold and bacterial wilt (20.1 and 17.2%, respectively). The two most important diseases for cucurbits were cucumber blight (55.6%, n=9) and cucumber wilt (33%). A few vegetable growers reported powdery mildew. About diseases in cabbage, 4.4% (n=45) reported cabbage blight and head rot as problematic diseases in cabbage production. Onion purple blotch was the most important disease (23.4%), followed by powdery mildew (6.4%). Like insect pests, farmers controlled vegetable diseases solely through synthetic chemicals. Ivory M72 (Mancozeb + Metalaxy) and Farmerzeb (Mancozeb) were reported as the most commonly used fungicides for control of powdery mildew.

Because of lack of proper records, 40 and 66.7% of cucurbit growers did not remember the fungicides they used to control blight and powdery mildew, respectively.

DISCUSSION

This article investigated insect pests and beneficial insects, diseases, and control methods, and knowledge on Integrated Pest Management (IPM) in vegetable crops specifically tomato, cucurbits, cabbage and onion. Based on the results, vegetable growers had some knowledge about pests and pest control. Vegetables were affected by many insect pests as presented in the results. Nonetheless, some pests were reported more frequently than others implying that they were well known by the vegetable growers. In tomato for example, although vegetable growers reported a number of insect pests, the most two commonly mentioned were tomato leaf miner (*Tuta absoluta*) and aphids (*A. gossypii*). In cucurbits, farmers mentioned frequently cucumber beetle (*D. undecimpunctata*) and cucumber fruit worm (*D. nitidalis*) while in cabbages they mentioned cabbage aphids (*B. brassicae*), and in onion it was onion thrips (*T. tabaci*) followed by aphids (*A. gossypii*).

Vegetables were attacked by many insect pests. This can trigger challenges regarding pest control in the context of limited knowledge of control methods. Pests affect vegetable productivity negatively and therefore can be one of the causes for poor productivity if they are not controlled effectively (Testen, 2017). Insect pests are destructive in the sense that they can eat and chew plant materials, and also can suck plant sap from phloem and xylem systems or from general tissue of foliage, roots and fruits (Maerere et al., 2020). They can also transmit viral diseases. This finally affects the whole plant. Specifically, insect pests cause reduction of yield and transmit diseases. Some of the diseases reported by URT (2004) in Tanzania are summarized in Table 10. Onion purple blotch disease was also previously mentioned as one of the most occurring disease in onions (Mamiro et al., 2014). Insect pests also increase farm cost and reduce market value of the vegetable crops (Imam et al., 2010). Thus, an intervention to control insect pests is important.

Membership in farmer organizations improves social capital and provides an avenue to the vegetable growers to learn, use and disseminate agricultural technologies. Farmer organizations are also conduit points for adoption of agricultural technologies before the technologies can diffuse to the rest of the farmers who have no membership status. They also help access to markets. Interestingly, membership in farmer organizations in Tanzania has positive effect on agricultural productivity and farmers' well-being (Msuta and Urassa, 2015). This suggests that lacking membership is a disadvantage to the farmers and therefore it is critical to promote farmer groups formation, membership and active participation of the vegetable growers in farmer organizations.

Although vegetable growers were knowledgeable about types of pests attacking vegetables and to some degree beneficial insects, some identified insect pest using vernacular languages. As such, it was difficult to have a common understanding about the pest in question. There was also limited knowledge among onion growers on beneficial insects.

Farmers' knowledge on pests and pest control is critical for increasing vegetable productivity and thereby improving farmers' livelihood. Pests can be controlled using different methods including natural, biological, cultural and mechanical methods (URT, 2004; James et al., 2010; Abanga et al., 2014). Although some vegetable growers could report alternative control methods, approximately all used synthetic insecticides. The study shows that the application of pesticides in vegetable production in the study area was high and the trend was increasing (Mtui et al., 2014; Kariathi et al., 2017). A considerable number of vegetable growers applied pesticides in a mixture. Yet, they had limited knowledge about tank mixing because of lacking specific instructions on labels, from extension officers or from agro-dealers who sell pesticides in a local market. This is in line with what was reported by Ngowi et al. (2007) in northern Tanzania.

There was also a failure to distinguish fungicides from insecticides. This implies that some vegetable growers had limited knowledge about pesticides. This was exacerbated by having different trade names assigned to pesticides with similar active ingredients. The most prevalent active ingredients were profenofos, abamectin and lambdacyhalothrin. The use of Thionex, which has endosulfan ingredient, explains limited knowledge of the farmers regarding pesticides. This is one of the Persistent Organic Pollutants (POPs), which contaminate the environment for a very long time (Kariathi et al., 2017). In addition, some insecticides used by vegetable growers were not registered to be used for insect pest control in vegetables. For example, although some used Actelic, it is registered for disinfestations of grain storage structures (URT, 2004). The use of these pesticides in vegetables may pose serious health risks to the farmers, consumers and the environment. It can also cause resistance to the insect pests and hence increasing pest populations. This complicates the issue of insect pest and disease control with implications on farmers' livelihood. There were also different brands of pesticides available in the local market. Because of limited knowledge on specific pesticides for controlling specific insect pests, vegetable growers used a number of insecticides to control one pest.

Vegetable growers in the surveyed areas had difficulties to correctly identify a disease and its specific control measures as most respondents resorted to providing descriptions of the disease symptoms rather

Table 10. Common vegetable diseases in Tanzania.

S/N	Tomato	Onion	Cabbage	Cucurbits
1	Late blight (*Phytophthora infestants*) Kiswahili name*: Baka jani chelewa*	Downy mildew (*Peronospora destructor*) Kiswahili name: *Ubwiri unyoya*	Blackrot (*Xanthomonas campestris*) Kiswahili name: *Uozo mweusi*	Powdery mildew
2	Early blight (*Alternaria solani*)	Purple blotch (*Alternaria porri)*	Downy mildew (*Peronospora destructor*) Kiswahili name: *Ubwiri unyoya*	Fusarium wilt
3	Powdery mildew (*Oidium lycopersicum)*	Storage rots (*Bortytis, Erwinia, Mucor, Fusarium)* Kiswahili name*: Uozo ghalani*	Alternaria leaf spot (*Alternatira* spp.)	Phytophthora crown/root rot
4	Bacterial wilt (*Pseudomonas solanacearum*)	-	Cabbage club rot (*Plasmodiophora brassicae*)	-
5	Fusarium wilt (*Fusarium oxysporum)* Kiswahili: *Mnyauko nyanya*	-	Black rot (*Xanthomonas campestris* pv. *campestris*)	-
6	Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) Kiswahili name: Madoa bakteria	-	Cauliflower mosaic virus (CaMV)	-
7	Tomato yellow leaf curl (TYLC)-virus transmitted by whitefly (*Bemisia tabaci*) Kiswahili names: *Rasta, Ngumi, Bondia*	-	Dumping off (*Fusarium* spp*., Rhizoctonia* spp.*, Pytium* spp. and *Phytophthora* spp.)	-
8	-	-	Bacterial soft rot *(Erwinia carotovora* var. *carotovora* and *Pseudomonas* spp*.*)	-

Source: URT (2004).

than naming the disease. In other cases, diseases were confused with nutrient deficiency or insect pest damage symptoms. Based on the results of this study, it is clear that the frequency of spraying pesticides was high, more so in cucurbits, tomato and onion. This is not surprising because the intention of the farmers was to eliminate pests in order to improve production. They had poor knowledge of determining when to spray and when not to spray based on threshold of the pests. This implies that farmers allocated more resources in terms of money, time and labour for insect pest and disease control. This definitely increased production cost. Although specific data on when the last spraying is done was not collected, the high frequency of spraying increases the likelihood of pesticide residues in the harvested produce, with implications on human health.

About IPM, nearly all vegetable growers had limited knowledge. This explains the reason why majority had limited knowledge on alternative pest control and therefore exclusively depended on chemical pesticides. Female farmers had basic ideas about IPM relative to male tomato growers. Having no idea about IPM implies that majority of the vegetable growers did not apply any of the IPM techniques. IPM encompasses coordinated systems of controlling pests that uses cultural and biological methods and therefore reduces use of pesticides (Supporting Sustainable Land Use, 2011). In other words, IPM uses multiple tactics to control pests. The techniques are critical for minimizing crop damage and losses; cost of control methods and negative environmental impacts. As such, IPM reduces cost of production and therefore imperative not only for livelihood through increased output but also for the physical environment, ecosystem and human health.

CONCLUSIONS AND RECOMMENDATIONS

The study makes the following conclusions. First, vegetable growers were at least able to mention important insect pests and diseases affecting vegetables. Farmers mentioned a larger number of pests in tomato compared to other vegetable crops. However, there was a challenge of using vernacular names in identifying insect pests and diseases and therefore difficult to have a common understanding. Secondly, while synthetic pesticides were solely used to control pests; vegetable growers had limited knowledge on thresholds of the pests and therefore the high frequency of spraying pesticides particularly in tomato, cucurbits and onion was not justifiable. Knowing threshold of pests is critical for farmers to optimize insecticide application, and thus minimize cost of production in terms of money, labour and time. Thirdly, vegetable growers had also limited knowledge about tank mixing and they were not aware about which pesticide controls which pest. Forth, almost all vegetable growers had limited knowledge about IPM such that they did not use alternative pest control methods apart from synthetic pesticides.

The study recommends that researchers and local government authorities at all levels should strive to make sure that vegetable growers have common understanding about important insect pests, diseases and appropriate control methods particularly IPM that employ multiple tactical techniques while minimizing environmental pollution. Different trainings should be offered to the vegetable growers. The most important ones include tank mixing, pest identification, scouting and threshold for pest management, and safe use of pesticides. Record keeping especially on type of pesticides used for specific purpose and when spray was done are among important things to consider during farmer training.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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