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Smallholder vegetable farmers in Northern Tanzania: Pesticides use practices, perceptions, cost and health effects

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Abstract

Smallholder farmers in Northern Tanzania grow vegetables that include tomatoes, cabbages and onions and use many types of pesticides to control pests and diseases that attack these crops. Based on the use of questionnaires and interviews that were conducted in Arumeru, Monduli, Karatu and Moshi rural districts, this study investigates farmers' practices, perceptions and related cost and health effects on vegetable pest management using pesticides. The types of pesticides used by the farmers in the study areas were insecticides (59%), fungicides (29%) and herbicides (10%) with the remaining 2% being rodenticides. Pesticides were bought from pesticides shops (60%), general shops (30%) and cooperative shops (10%). The pesticides were supplied in containers ranging from 0.5 to 5 l or in packets ranging from 0.5 to 25 kg. Vendors often dispensed smaller quantities of pesticides in unlabelled containers. About a third of the farmers applied pesticides in mixtures. Up to 90% of this third had a maximum of 3 pesticides in a mixture. In all cases, there were no specific instructions either from the labels or extension workers regarding these tank mixtures. More than 50% of the respondents applied pesticides up to 5 times or more per cropping season depending on the crop. Insecticides and fungicides were routinely applied by 77% and 7%, respectively. Fifty-three percent of the farmers reported that the trend of pesticide use was increasing, while 33% was constant and 14% was decreasing. Sixty-eight percent of farmers reported having felt sick after routine application of pesticides. Pesticide-related health symptoms that were associated with pesticides use included skin problems and neurological system disturbances (dizziness, headache). Thirty-nine percent of farmers reported spending between 20 and 130,200 Tanzanian shillings (0.018–116 US dollars) in a year on health due to pesticides. These results will contribute to the reformation of pesticide policies for safe and effective use of pesticides by smallholder farmers in Tanzania.

Keywords: Northern Tanzania; Smallholder farmers; Vegetables; Pesticides; Health; Cost

1. Introduction

A wide range of pesticides is used for pest management and vector control in agricultural areas, but many farming communities in Northern Tanzania are not adequately informed about the hazards associated with the chemicals (Ngowi, 2003). As a result, farmers use pesticides without full understanding of their impact on human health and the environment. Humans come into contact with pesticides, whether in the field, during pesticide application, weeding, pruning, harvesting, re-entry to collect fire wood or vegetables, or in their homes, to kill mosquitoes, cockroaches, fleas and flies. Storing pesticides may lead into acute and/or chronic exposures, with adverse health consequences. Although the inhalation, dermal and oral routes of exposure are the most common, pesticide residues in food and water may add to indirect exposures common in the general population.

Pesticide-related illness suffered by one or more members of household may affect the overall performance and the productivity of the family farm since households

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normally supply labour input, especially in smallholder agriculture in developing countries. The level of health costs has been estimated in some studies in other countries and is believed to be closely related to the level of socio-economic development and the context of the prevailing culture (Ajayi, 2000). However, in Northern Tanzania there has never been a comprehensive study to determine the costs of adverse effects of pesticides usage on the environment and human health. There is therefore the need to develop appropriate tool for estimating the real cost of pesticide usage in Tanzania to fill a knowledge and information gap so as to provide better means to develop appropriate pesticide policy in the country.

The costs of health problems and other environmental effects including the degradation of the biological capital of the ecosystems (Ajayi, 2005) due to pesticides use in agriculture and public health are generally externalized in estimations of the economic burdens and benefits of pesticides in Tanzania and other parts of the world. Medical expenses (consultation fees and medicine); costs of recuperation (meals, medicines, doctors or hospitals); transportation costs (to health care facility); labour losses (for victims and their caretakers); are rarely included in analysis of the costs of pesticides. The main reason for not costing health problems, particularly medical costs, is due to the fact that local health officials do not often diagnose symptoms in relation to exposures, and are not adequately trained to identify adverse effects of pesticides (Ngowi et al., 2001; Ngowi and Partanen, 2002). Similar findings of low awareness amongst health care providers of the problem of pesticide poisoning have been reported in other parts of East Africa (Mbakaya et al., 1994; Ohaya-Mitoko, 1997), South Africa (London and Bailie, 1999), Costa Rica (Wesseling et al., 1997), Côte d'Ivoire (Ajayi, 2000) and in Ghana (Ntow et al., 2006). In addition, most farmers do not keep records of their expenditures, as they do not appreciate its importance. Also, many of those vulnerable to pesticide-related symptoms are poor farmers who are often illiterate.

1.1. Objectives

This study was conducted as part of a collaborative South African–Tanzanian programme of research into the health and economic consequence of pesticide exposure and aimed at generating data to develop a tool to collect information on the costs of pesticide usage. The purpose of the research is to provide data for pesticide policy aimed at pesticide exposure reduction and hence reduced health consequences due to pesticides, whilst still allowing farmers to produce cost-effectively sustainable and environmentally friendly. This paper describes pesticide use practices; perceptions, cost and health effects amongst smallholder vegetable farmers in Northern Tanzania as part of contribution to the overall collaborative programme.

2. Material and methods

2.1. General study design and information

The study entitled "Health and Economic Consequences of Pesticide Usage" was launched in October 2003 in Tanzania (Tropical Pesticides Research Institute) and South Africa (University of Cape Town) under the sponsorship of the Fogarty International Center through the National Institutes of Health, United States of America (USA). The study aimed at exploring the relationship between health, the environment and economic development in relation to pesticide exposure in the two developing countries of Tanzania and South Africa. The study included developing robust, valid and reliable methodologies for assessing exposure, health outcomes and to pilot risk perception methodologies applicable for developing countries and methods to cost the consequences of pesticide exposures and effects. The study also gathered descriptive policy data and preliminary pesticide poisoning prevalence and incidence estimates. The present study is based on the sub-study to develop methods to cost the consequences of pesticide exposures and effects.

2.2. Target areas and population

Scientists with long experience in pesticide-related research conducted the study between March and June 2005. It consisted of interviews with farmers and farm workers in rural areas in Northern Tanzania where horticultural crops (vegetables, flowers, fruits) were mostly cultivated using farm inputs, particularly pesticides. The sample farmers from whom information was collected comprised of 61 small-scale farmers selected from Arumeru, Monduli, Karatu and Moshi rural districts. The sites were selected based on crops grown (horticultural crops), pesticide usage, ease of accessibility and closeness to the TPRI (furthest was Mang'ola which is approximately 300 km), cooperation from local leaders and willingness of farmers/farm workers to participate. The study group was selected with the help of village leaders and agricultural extension staff on the grounds that they cultivate crops that require application of chemical pesticides.

2.3. Data collection

A questionnaire consisting of structured, semi-structured and unstructured items was designed based on published literature on the subject as well as experiences of the authors in the field. Data were collected through a farm survey by face-to-face interviews with farmers/farm workers and field observations during farming activities. The questionnaire was designed in English and translated into Kiswahili, the national language, which is understood by the majority of the farmers and pre-tested using small samples of farmers in the same areas before using it in this study.

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Table 1
Type of information collected during survey

Type of information	Specific data collected in the questionnaire
General farm system and practices	Biodata (name, sex, date of birth, marital status and contact address) Source of income Crops, farm acreage and production per season Duration in farming activities Extent and severity of pest problems
Pesticide use practices	Pesticides used and sources Trends in pesticide use (increasing, decreasing or constant) Types and cost of spraying equipment, spares and repairs Pesticide use practices (e.g. mixtures and doses, application techniques, disposal of pesticides containers) Characteristics of pesticide stores and storage costs
Human health cost of pesticides	Effects of pesticide exposure (e.g. symptoms and illness as reported by farmers) Costs (expenditures incurred by farmers in treating illness due to pesticides exposure) Farmers' knowledge on impact of pesticide to the environment and pesticide resistance

The data collected (relevant to this paper) included personal matters and general farm system and practices; pesticides use practices, and human health costs of pesticides as indicated in Table 1.

To avoid bias, the questionnaire avoided leading questions. For example, to identify whether pesticides containers were disposed off in hazardous ways, the question was phrased as "How do you dispose off empty pesticide containers?" without prompting any particular method of disposal. Similarly, symptoms related to pesticide application were sought by asking "have you felt sick or abnormal during and after application of pesticides?" and the interviewer recorded whatever symptoms were mentioned by the interviewee without leading.

Computer data entry in Microsoft access was done with assistance from a statistician from the National Medical Research Institute and analysis was done using SAS statistical software (SAS 9.1). Statements made on open-ended questions that were not coded were also used to substantiate the numerical data.

3. Results

3.1. Types of pesticides used by farmers

The farmers, the majority of whom were males (89%) with mean age of 50 years, ranging 25–76 years, reported the use of 41 different pesticides. The study showed that, of the different pesticide formulation types used by farmers in the area most were insecticides (59%), fungicides (29%) and herbicides (10%) with the remaining 2% being rodenticides (Table 2). Carbofuran, a broad-spectrum pesticide that kills insects, mites and nematodes, zinc phosphide, a rodenticide and methomyl an insecticide were the only WHO Class Ib (highly hazardous) recorded in use. Of the Class II (moderately hazardous), III (slightly hazardous) or U (unlikely to present acute hazard) types in use, 20% contained chemicals that were suspected to be endocrine disruptors, 24% were cholinesterase inhibitors and 7% each carcinogens and potential carcinogens. Eight out of 42 were unregistered for general use.

3.2. Availability of pesticides

Pesticides sources were within easy reach by farmers. One out of five farmers got their pesticides within a kilometre from their home with more than 50% spending less than 2 h for a round trip. A few of them (10%) travelled as far as 20 km using public transport that took less than 8 h. The primary source of pesticides in the farming areas was pesticide shops (60%), followed by general shops (30%). Cooperatives societies (10%) represented a minor role as source of pesticides. The pesticides were supplied in containers ranging from 0.5 to 5 l or in packets ranging from 0.5 to 25 kg. One litre and 1 kg containers were common as well as dispensing of smaller quantities in unlabelled containers by vendors. Most farmers stored pesticides in multipurpose storage structures together with food containers and farm implements.

Insecticides used included pyrethroids (such as cypermethrin, deltamethrin, permethrin and lamda-cyhalothrin); organophosphates (such as pirimiphos-methyl, profenofos, chlorpyrifos, fenitrothion) and carbamates (carbofuran). The most popular fungicides were copper based such as copper oxychloride, copper hydrochloride and copper sulphate although mancozeb was also in use. The type and amount of pesticides used in different crops depended on the pest population and their potential damages to the crop as well as farmers' perception regarding pest management practices.

About a third of the farmers apply pesticides in mixtures. There were combinations of up to 5 pesticides in a single tank mixture. Up to 90% of this third had up to three pesticides in a mixture (Table 3). Farmers did not have specific instructions either from the label or from extension staff regarding these tank mixtures. They reported that tank mixing was favourable because it served time, labour and cost since more than one pesticide could be applied in a single spray.

3.3. Frequency of pesticide application

Farmers used knapsack sprayers, which were easily available, relatively cheap and easy to operate and maintain. More than 50% of the respondents applied pesticides up to 5 times or more per cropping season depending on the type of crop. Fifteen percent of farmers reported applying pesticides 16 times or more per cropping season (Fig. 1). The highest frequency was reported on

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Table 2
Types of pesticides used in small-scale vegetable farms in Northern Tanzania, classified using the WHO Hazard Class and health effects, 2005

Trade name	Common name	WHO Class[a]	Health effects[b]	Target pests	Registration status[c]
2-4D	2-4D amine	II		Weeds	R
Actellic 50EC	Pirimiphos-methyl	III	CI,SE, PC	Weevils	R
Actellic Super dust	Pirimiphos-methyl + permethrin	NK	CI, SE, PC	Cutworms, armyworm, stem-borer	R
Alto	Cyproconazole	III		Leaf-rust	R
Ashes		NK		Stem-borer, stalkborer	U
Bayleton	Triadimefon	III	PC, SE	Blight	R
Blue Copper	Copper sulphate	II		Leaf-rust, blight	U
Cobox	Copper oxychloride	III		fungus	R
Cypercal	Cypermethrin	II	SE, PC	Larger-grain-borer	R
Decis	Deltamethrin	II		fruit-borer	R
Diazinon	Diazinon	II	CI	Stalkborer, stem-borer, leafhopper, leaf-miner, beetle	R
Dimethoate	Dimethoate	II		Insects	R
Dithane M45	Mancozeb	U	SE, C	Fruitfly, blight, downy-mildew, leaf-rust, wilting	R
Dursban	Chlorpyrifos	II	CI	Stem-borer, cutworms, armyworm, bollworm, thrips, beetle, aphids, leafminer, stalkborer	R
Dynamec	Abamectin	II		Insects	R
Fenesta		NK		Weeds	U
Fenom c		NK		Thrips, insects, fruitrote	U
Funguran	Copper hydoxide	III		Leaf-rust	R
Furadan	Carbofuran	Ib	CI	Stalkborer, nematodes	R
Helarat	Lamda-cyhalothrin	II	SE	Thrips	R
Impact	Flutriaflo PP	III		Leaf-rust	R
Ivory 80WP	mancozeb	U	SE, C	Blight	R
Karate	Lamda-cyhalothrin	II	SE	Armyworm, beetles, stem-borer, caterpillar, cutworms, larger-grain-borer, weevils, aphids, fruitfly, spidermite, stalkborer	R
Keshet	Deltamethrin	II		Insects	R
Lannate	Methomyl	Ib		Butterfly	U
Majester		NK		Spidermite	U
Mamba	Glyphosate	U		Weeds	R
Phostoxin	Aluminium phosphide	NC		Thrips	R
Polytrin	Cypermethrin	II		Thrips, insects	R
RedCat	Zinc phosphide	Ib		Rats	U
Ridomil	mancozeb + metalaxyl	NK	SE, C	Blight, spidermite	R
Rogor	Dimethoate	II		Stalkborer	U
Ronstar	Oxadiazon	U		Stem-borer	U
Roundup	Glyphosate	U		Weeds	R
Selecron	Profenofos	II	CI	Whitefly, spidermite, fruit-borer, stem-borer, insects, thrips, aphids	R
Shumba dust	Fenitrothion + deltamethrin	II	CI	Larger-grain-borer	R
Sumithion	Fenitrothion	II	CI	Stem-borer	U
Thiodan	Endosulfan	II	SE	Larger-grain-borer, stem-borer, leafminer, red-ants, beetle	R
Thionex	Endosulfan	II	SE	American-bollworm, aphids, mites, insects, leafminer, stalkborer	R
Thiovit	Sulphur	U		Blight, leaf-rust	R
Tilt	Propiconazole	II		Insects	R

[a] 1a = extremely hazardous; 1b = highly hazardous; II = moderately hazardous; III = slightly hazardous; U = unlikely to present acute hazard in normal use; NC = not classified; NK = not known.
[b] CI = cholinesterase inhibitor; C = carcinogen; PC = possible carcinogen; SE = suspected endocrine disruptor (ILO, 2005).
[c] R = Registered for general use (full, provisional or restricted); U = not registered for general use (not in the register, experimental use).

Table 3
Pesticide mixtures used by small-scale vegetable farmers in Northern Tanzania

Pesticides combination	Types of pesticides	Target crops
Impact and 2-4D	Fungicide + herbicide	Onions and tomatoes
Ridomil and selecron	Fungicide + insecticide	Tomatoes, onions and cabbages
Selecron and fenom C	Two insecticides	Onions and cabbages
Thiodan and karate	Two insecticides	Onions and cabbages
Thiodan and blue copper	Insecticide + fungicide	Onions, cabbages and tomatoes
Selecron, karate and fenom C	Three insecticides	Onions and cabbages
Polytrin, fenom C, dursban and cypercal	Three insecticides + one fungicide	Onions, cabbages and tomatoes
Thiovit, selecron, ridomil dithane and karate	Four insecticides + two fungicides	Tomatoes

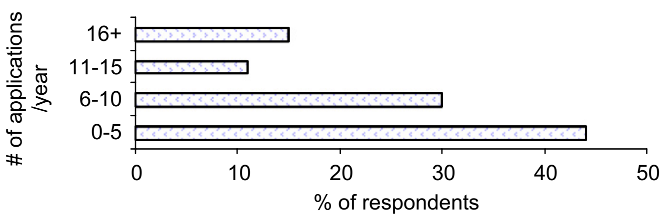

Fig. 1. Number of pesticide applications in vegetable farms in Northern Tanzania per cropping season.

onions, which were more than 16 applications per cropping season followed by tomatoes and cabbages. More than three quarters (77%) of the farmers interviewed reported routine application of insecticides and 7% reported routine application of fungicides. Routine application implies regular, usually weekly and habitual application to prevent an anticipated pest attack.

3.4. Farmers' perception on trend in pesticide use

Fifty-three percent of farmers who responded to the question on "What is the trend of your pesticide use during the past 5 years?" said the trend was increasing, while 33% felt it was constant and 14% felt it was decreasing. Table 4 shows the reasons given by farmers for the trends in pesticide use. The reasons were ranked and the first three were the commonest.

3.5. Farmers' reports of pesticide poisoning symptoms

Sixty-eight percent of farmers reported having felt sick in the previous year after routine application of pesticides. The most common symptoms that were reported by the interviewees are shown in Table 5. Dermal effects (34%), dizziness (31%) and headache (31%) were more commonly reported and nausea (18%) and stomach ache (15%), less commonly reported.

3.6. Costing

In calculating health costing, the following were considered: consultation fees, cost of diagnosis, travel to and from medical facilities, cost of time spent in the

Table 4
Reasons given for the trends in pesticide use in vegetable farms in Northern Tanzania, 2005

Trend in pesticide use reported by respondents	Reasons given by the respondents for their opinion[a]
Opinion: increasing trend (53%)	Ineffective pesticides
	Pest resistance
	Increase in pest population
	Increase in pest numbers
	Increase in insect damage
	Increase in farm acreage
	Increase in insect pests
	Increase in plants
Opinion: constant (33%)	Pesticides are effective
	Same acreage, farm size
	Correct instructions and effective pesticides
	Drought and same farm
	Fewer insect pests
	Same application throughout
	Same pesticides used
Opinion: decreasing trend (14%)	Good farm preparation
	Heavy rains
	Drought
	Less crop
	Price increase
	Reduced farm area
	Unavailability of pesticides

[a]Reasons listed in descending order of frequency.

Table 5
Self-reported pesticide-poisoning symptoms amongst vegetable farmers in Northern Tanzania, 2005 ($n = 61$)

Symptom	Frequency	Frequency (%)
Skin problems	21	34
Dizziness	19	31
Headache	19	31
Excessive sweating	19	31
Sneezing	17	28
Poor vision	14	23
Cough	13	21
Nausea	11	18
Stomach ache	9	15

treatment centre and out of productive work, and the costs of drugs and other medical supplies. Other mitigation efforts like drinking milk and local brews before and after pesticides application were also considered. Valuation of the monetary costs for pesticides use showed that 61% of farmers reported spending no money on health costs of pesticides while the remaining 39% reported spending between 20 and 130,200 Tanzanian shillings (0.018–116 US dollars) in a year. One out of three paid less than a dollar as fare for travel in public transport to purchase pesticides. Most farmers (two thirds) purchased pesticides only 2 times a year. However, records of these expenditures were not documented as farmers were only relying on memory.

4. Discussion

The smallholder vegetable farmers depended heavily on use of pesticides for control of different pests and diseases and over 40 different formulations were used. This is probably because they believe that the only solution to pest problems is to spray more frequently and using different types of pesticides (Dinham, 2003). Previous research in some of the same study areas (Ngowi, 2003) showed that farmers were not receiving agricultural extension services, and relied heavily on pesticide use when dealing with pest problems but were constrained by the lack of appropriate knowledge. However, pesticide usage in the study area seems to be highly influenced by pesticides vendors who were carrying out their business right in the farming communities and very interested in achieving large sales of their pesticides. This situation is also true in many developed countries where the choice of pesticides to be used by farmers is influenced by the suppliers (Snoo et al., 1997; Epstein and Bassein, 2003). In African countries, many government extension programs encourage the use of pesticides (Abate et al., 2000), but do not consider their effects in the environment and health risks. As a result and coupled with lack of basic knowledge of pesticides, farmers' decisions on what pesticides and how to use do not have a bearing on health or safety of the environment. Epstein and Bassein (2003) observed that farmers used more pesticides because they based the applications on calendar spray pesticides programme without necessarily giving much priority to health and environmental considerations.

Insecticides were the most used because insect pests were the most serious problem in vegetable production in the study area. This was followed by fungicides usage, indicating that fungal attacks ranked second to insect pests. Herbicides were least in use probably because weeding could easily be done manually by deploying community members. This is contrary to the situation in Ghana where herbicides are the predominant pesticides type in use in vegetable production (Ntow et al., 2006). The community members including women and children were deployed in duties such as transplanting, weeding and harvesting. It was common scenery in this study to see women and children transplanting, weeding and harvesting especially in onion farms. This trend of labour division exposed the whole community to pesticides hence the majority of households in the farming communities were likely to be adversely affected by pesticides in one way or the other. Although in this study it was observed that insecticides were the most commonly used pesticides, usually amounts and types of pesticides used have been reported to show important differences among countries and among regions within one country depending on the type of agricultural production and level of economic development. In Ghana, for example, herbicides were the class of pesticides most used in vegetable farming (Ntow et al., 2006) with a perception by farmers that herbicides use was able to suppress weeds for a longer time and over a wider area than manual weeding with hoe.

The tank mixture of pesticides observed in this study indicates that farmers lack basic knowledge of pesticides. Usually label instructions do not cover mixtures of three or more pesticides and give no information on the compatibility of inert ingredients such as emulsifiers and wetting agents. It is riskier to mix two different types of formulations for example wettable powders with emulsifiable concentrates (e.g. Thiodan and Blue Copper in Table 3). Smit et al. (2002) observed that there was an interaction between fungicides, insecticides and water mineral content that influenced the efficacy of individual pesticide against fungal pathogens and insect mortality and some tank mixtures induced phytotoxicity on tomato. Mixtures of insecticides generally result in the simultaneous development of resistance (Metacalf, 1980). There is limited information on the reaction and effects of the mixtures observed in this study. In addition, farmers did not consider that unspecified tank mixing of pesticides could be less effective and cause adverse effects to their health or the environment. Instead, the tank mixing was carried out to save time, labour cost and with anticipation of high efficacy in pests and diseases control. Sherwood et al. (2005) reported that potato farmers in Ecuador were mixing pesticides mainly to reduce costs associated with spraying. The tank mixtures observed in this study and that reported by Sherwood et al. (2005) indicate that they were purely on individual thinking and feelings and not on label instructions or advice from extension workers.

In general, the frequencies of pesticides application by farmers were high. This is as a result of preventive measures that farmers were practicing as compared to curative application that requires application after observing pest problem. This is probably due to lack of extension services that could offer appropriate advice. Such heavy use of pesticides may result in frequent contact with pesticides, which can lead to significant health problems.

The trend of pesticides use by farmers over years was probably based on farmers' knowledge on pesticide application in relation to effectiveness of pesticides, pests, farm size and price and weather condition. The use of carbofuran, a highly hazardous carbamate pesticide, which is applied as granules in the soil to control nematodes, can cause acute effects despite the fact that the formulation type is solid to mitigate its risks. Carbofuran can be fatal if inhaled, swallowed or absorbed through the skin, even though the effects of contacts and/or inhalation may be delayed due to its formulation (Santo et al., 2002). The effects of exposure even of a short duration can be delayed but there is a possibility of cumulative effects (Gupta, 1994).

The risk of long-term effects of the pesticides that were being used in the study area is high especially due to exposure to carcinogens, possible carcinogens and suspected endocrine disruptors. The pesticides were being misused e.g. spraying when there were no pests or diseases and unnecessary overdosing; mixed wrongly, mishandled, for example, farmers measured small quantities using cups and/or spoons, and used food containers to keep pesticides. Although fungicides are not easily observed to cause serious and acute damage to farmer's health, it has been reported that there is a long-term risk for cancer development and endocrine disruption resulting from farmer's exposure to fungicides containing mancozeb (Novikova et al., 2003). The fungicides chlorothalonil and maneb have been identified as risks factor for dermatitis among banana plantation workers in Panama (Penagos et al., 1996) and potato growers in Equador (Cole et al., 1997), respectively. The dithiocarbamate family of fungicides are suspected to have reproductive (Restrepo et al., 1990) and mutagenic effects in human cells (Puz-y-Mino et al., 2002).

A large proportion of the farmers in this study reported ill health symptoms after spraying, which were generally considered as common phenomena after working in the fields. Kishi et al. (1995) reported that farmers assume that pesticides poisoning symptoms were normal so they get used to them. This may explain why there were few farmers who reported to the health care centres for treatment resulting from pesticides use and hence the reason for low expenditure on health costs. Similar studies carried out in Indonesia (Kishi et al., 1995) and in Côte d'Ivoire (Ajayi, 2000) report that pesticide applicators tended to accept a certain level of illness as an expected and normal part of the work of farming and therefore do not report the symptoms in official health centres for formal medical assistance.

Health and environmental problems cannot be isolated from economic concerns due to the fact that inappropriate pesticide use results not merely in yield loss but also in health problems and possible air, soil and water pollution. The problem of farmers' health should be an important concern for policymakers when looking at the economic and efficiency of pesticides in horticultural production. Data from this study will inform ongoing efforts in the region to promote upstream policy interventions to reduce hazardous pesticide exposures for vulnerable farmers (Ngowi and London, 2006).

Other factors, such as the strong influence of pesticides vendors and quick results obtained in the short term after pesticide applications were presumably encouraging farmers to rely more on pesticide use than on other pest control methods. This high dependence on pesticides by vegetable farmers is also an indication that they are not aware of other pest management strategies that are effective, inexpensive and yet friendly to the environment. Pest management strategies including intercropping (Legutowska et al., 2002) and tillage type and crop rotation (Hummel et al., 2002) have been shown to significantly reduce insect pests. There is a need to bring to the attention of these farmers the existing alternative pest management strategies that are cost-effective and environmentally friendly. In Zimbabwe, although small-scale vegetable farmers use some cultural control methods and occasionally botanical pesticides, pest control is predominantly by the use of synthetic pesticides (Sibanda et al., 2000).

One objective of this study was to develop methods to quantify economic externalities of pesticide usage. To some extent, this was met in that the questionnaires were able to identify relevant direct costs with regard to medical consultations, transport and purchase prices of pesticides. However, because of poor record keeping, and the willingness of farmers to accept ill health as inevitable after pesticide application, we underestimated costs and were not able to fully capture both direct costs related to purchasing of pesticides and indirect costs of lost productivity. Further refinement of the study instruments will be needed to generate more accurate cost data. Ongoing research is also needed to confirm that the various symptoms reported were caused by pesticide exposure and hence advise farmers on how to protect themselves and/or seek treatment for such effects and avail appropriate expenses. Beyond the scope of our study is a much larger question as to whether pesticide exposure potentially increases the risk for other conditions that are major contributors to the burden of disease in developing countries, such as malaria and HIV/AIDS. Such a relationship would have very large implications for the externalization of the costs of pesticide usage, and warrants careful future investigation.

5. Conclusion

This study provides valuable information on the pesticides used in pests and diseases control in vegetable production, perceptions of pesticide usage, trends in pesticide uses and health symptoms by smallholder vegetable farming communities. Findings from this study strongly indicate that the smallholder vegetable farmers lack appropriate knowledge on safe handling and use of pesticides. This is attributed to by almost absence of extension services and training. This information can be used to develop a training programme on pest management especially on pesticide use in agriculture and hence contribute to reform of pesticide policy in Tanzania to improve extension services and farmers productivity. There are also strong indications that there are substantial human health problems associated with the use of pesticide in horticultural farming in Tanzania but these are inadequately documented. In addition, the costs of farmers' health effects and environmental problems caused by pesticide use have not been included in the total cost of vegetable production and warrant further study to generate appropriate data on which to base policy.

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