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Use of Chemical Pesticides in Ethiopia: A Cross-Sectional Comparative Study on Knowledge, Attitude and Practice of Farmers and Farm Workers in Three Farming Systems

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ABSTRACT

Chemical pesticides, regardless of their inherent hazard, are used intensively in the fast changing agricultural sector of Ethiopia. We conducted a cross-sectional pesticide Knowledge, Attitude and Practice (KAP) survey among 601 farmers and farm workers (applicators and re-entry workers) in three farming systems [large-scale closed greenhouses (LSGH), large-scale open farms (LSOF), and small-scale irrigated farms (SSIF)]. Main observations were that 85% of workers did not attain any pesticide-related training, 81% were not aware of modern alternatives for chemical pesticides, 10% used a full set of personal protective equipment, and 62% did not usually bath or shower after work. Among applicators pesticide training attendance was highest in LSGH (35%) and was lowest in SSIF (4%). None of the female re-entry farm workers had received pesticide-related training. Personal protective equipment use was twice as high among pesticide applicators as among re-entry workers (13 versus 7%), while none of the small-scale farm workers used personal protection equipment. Stockpiling and burial of empty pesticide containers and discarding empty pesticide containers in farming fields were reported in both LSOF and by 75% of the farm workers in SSIF. Considerable increment in chemical pesticide usage intensity, illegitimate usages of DDT and Endosulfan on food crops and direct import of pesticides without the formal Ethiopian registration process were also indicated. These results point out a general lack of training and knowledge regarding the safe use of pesticides in all farming systems but especially among small-scale farmers. This in combination with the increase in chemical pesticide usage in the past decade likely results in occupational and environmental health risks. Improved KAP that account for institutional difference among various farming systems and enforcement of regulatory measures including the available occupational and environmental proclamations in Ethiopia are urgently needed.

KEYWORDS: chemical pesticides; Ethiopia; farm types; knowledge attitude practice; training

INTRODUCTION

Ethiopia, the second populous nation in Africa with 85% of its population (currently estimated to be at 96.6 million individuals) living in rural areas, depends on the agricultural sector for necessities and as a source of employment. The agricultural sector currently contributes 47% of the Gross National Product (Ethiopian economy, 2015). In the past decade, there has been a strong intensification in agriculture production. Particularly in emerging farming systems [large-scale closed greenhouses (LSGH) and small-scale irrigation farms (SSIF)] with the aim to increase crop production as to alleviate the chronic food security problem in the country and increase national income through export of agricultural products like cut flowers and vegetables. Agricultural development policies in many developing countries have resulted in an increase in the use of inorganic fertilizers and chemical pesticides as a means to increase agricultural production (Ngowi, 2003).

Pesticides are one of the vital inputs in agriculture to prevent loss of production, but if not properly handled and/or managed they could create major environmental and human health risks (Vergucht, 2006). These risks could be high particularly for those occupationally exposed (McCauley, 2006). Occupational pesticide exposure can occur directly during mixing and pesticide application and indirectly while performing re-entry tasks in pesticide-treated crops or by take home exposure. Pesticide exposure can occur through the skin (dermal uptake), via the respiratory system (inhalation), or via the mouth (ingestion) and may result in health effects like ocular, dermal, cardiovascular, gastro intestinal, carcinogenic, endocrine disruption, developmental, neurological, and respiratory effects (Damalas *et al.*, 2011; Ntzani *et al.*, 2013).

Studies in developing countries, done mainly among male pesticide applicators, have often indicated unsafe use (handling and management) of pesticides. For example, it has been reported that a majority of the farmers in Ghana do not properly wear protective measures (Ntow *et al.*, 2006); that there is a negligible use of protective clothing, among small-scale farmers in the African countries of Benin, Ethiopia, Ghana, and Senegal (Williamson *et al.*, 2008); and that female farmers have limited access to pesticide training, in South Africa (Naidoo *et al.*, 2010).

Though Ethiopia has endorsed many proclamations in order to minimize and control occupational and environmental risks in general and pesticides in particular (Pesticide registration and control proclamation number 674/2010, Labor proclamation number 277/2003 and Environmental pollution control proclamation number 300/2002), previously conducted pesticide-related Knowledge, Attitude and Practice (KAP) studies in Ethiopia have indicated that farm workers had limited knowledge on pesticide hazards, inadequate awareness about safe pesticide management, and poor hygienic and sanitation practices (Mekonnen and Agonafer, 2002; Amera, and Abate, 2008; Karunamoorthi *et al.*, 2011). All previous KAP studies done in Ethiopia were focused on pesticide applicators, small-scale non-irrigated farms (SSNIF); non-commercial subsistent farmers producing mainly maize or large-scale open farms (LSOF). As agricultural practices have changed dramatically in recent years, we repeated and extended the KAP survey to current farming systems including emerging ones where pesticide usage is expected to be higher due to production of horticultural crops for commercial purposes [large-scale closed horticultural greenhouses (LSGH) and small-scale irrigated farms (SSIF)] and included both applicators and re-entry workers.

METHODS

The study was conducted in the Central Eastern part of Ethiopia where abundant hydrological resources exists from the Rift valley Lakes and Awash River (Fig. 1). Farms in the area can be divided in four farming systems. Three of the farming systems produce commercial crops on which use of agrochemicals including pesticides is expected to be high due to production of different kinds of horticultural crops: roses and cuttings in LSGH, vegetable, fruit and cotton in LSOF and mainly vegetables such as onions and tomatoes in SSIF. Crops produced in these farming systems are mainly for export purposes and for local consumption mainly in the capital city, Addis Ababa. We did not include the farming system of small subsistence (non-commercial) farms due to their low use of pesticides.

Six hundred one farm workers comprising of 256 pesticide applicators and 345 re-entry workers were included in the study. Applicators were defined as farmers and farm workers who are directly involved in

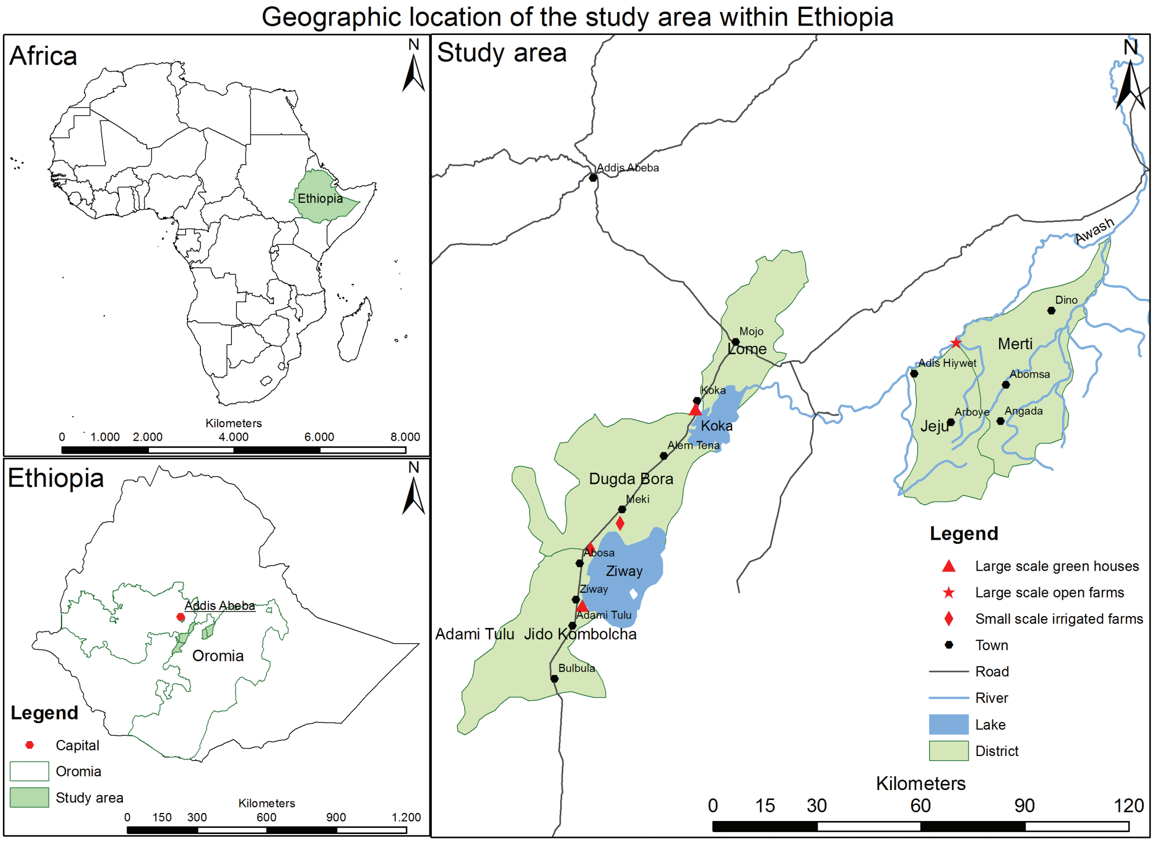

Figure 1 Location map of the study area.

pesticide application-related activities (i.e. pesticide mixers/loaders, pesticide sprayers, and application supervisors) whereas re-entry workers were defined as workers who usually enter the pesticide sprayed fields after spraying activities or handle the produce (i.e. harvesters, pesticide assessors, irrigation workers, irrigation supervisors, packing and sorting workers, transport/push car workers).

Study subjects were selected and invited to participate if they had been working on the farm for the past 12 months. Participation was on an anonymous and voluntary basis and verbal consent was obtained from all the participants after explanation of the objectives of the study, confidentiality of the information they provide, their right to ask any question during the interview and even to stop participating at any time.

In this study, our aim was to include all applicators and due to the much larger number of re-entry workers present in the farming systems a random selection from all re-entry workers per each of the selected farms. Due to uneven distribution of pesticide applicators and re-entry workers in farms of different farming systems, there was a slight difference in the selection process. Generally, in SSIF there is at least a farmer or farm worker (usually applicator) and if it is a harvesting day re-entry workers. In the case of LSGH, usually there are few applicators on a farm in comparison to re-entry workers. Due to large number of re-entry workers, we randomly selected a subset of re-entry workers as to obtain general information on re-entry. Similar to LSGH in LSOF there are few applicators on a farm while there are many more re-entry workers do their work scattered on a large area (which limits availability). We therefore established interview spots in LSOF where all re-entry workers available for interview at the interview spots in the selected units and all applicators present during the 8 days of the survey, 2 days per each interview spot were included in the study.

Recruitment of farm workers in SSIF was done by randomly selecting five primary farmers' cooperatives from the Meki–Batu vegetables and fruit growers' cooperatives union which operates in the study area including Adami Tulu and Dugda Bora districts (Fig. 1). Each member's farm was visited based on the list obtained from the farmers union, all farmers and farm workers (applicators and re-entry workers) present at each farm were invited to participate.

For the survey in the LSOF, in order to increase accessibility to the re-entry farm workers four units were randomly selected where an interview spot was established per unit, two from each of two big LSOF i.e. Merti-jeju (4 units) and Nuraera (5 units) which are under umbrella of Upper Awash Agro-Industry Enterprise (UAAIE) located in Merti and Jeju districts.

In the case of LSGH, two farms were randomly selected from two clusters in the study area (Zeway cluster with five farms, and Koka cluster with four farms which are 68 km apart). All application and re-entry workers were invited, randomly selected from a list obtained from farm managers with a sampling proportion of about 10%.

The survey questionnaire was developed by researchers from Utrecht and Addis Ababa University based on standardized questionnaires which were previously used in east Africa (Ohayo-Mitoko, 1997; Mekonnen and Agonafer, 2002). For the purpose of the described study, the questionnaire was translated to Amharic (the national language of Ethiopia) and back translated to English to check its consistency and piloted in 32 farmworkers (21 males and 11 females), whose answers were included in the final study.

The selected study subjects were interviewed by two trained data collectors using a structured open-ended and close-ended questionnaire. In case of close-ended questions in addition to 'yes' and 'no' options all other options were mentioned depending on the question, e.g. for the knowledge-related question of 'who provided the training?' all answering options of 'Agricultural extension service', 'Local cooperatives ', 'Ethiopian horticultural association', 'Health extension service', 'The employer farm' and 'Any other(specify)' were provided.

The questionnaire has five sections to gather information on sociodemographic factors, pesticide-related KAP and pesticide use and intensity: (i) The sociodemographic part consisted of five questions which were both open-ended and close-ended, e.g. what is highest educational level you have attained?, (ii) The pesticide use and intensity-related part comprised eight questions which were both open-ended and close-ended, e.g. How many (kg+l) of pesticides do you use per a spraying day? (iii) The pesticide-related knowledge part consisted of six all close-ended questions, e.g. Have you attained any chemical pesticide-related training, (iv) The pesticide-related attitude part consisted of five questions which were all close-ended, e.g. Where do you store pesticide or pesticide leftovers?, (v) The pesticide-related practices part consisted out of four questions which were also all closed ended questions, e.g. Do you usually take a bath after pesticide-related work?

Since the activities mentioned under the pesticide-related attitude part of the questionnaire and a question related to measurement of pesticide in pesticide-related practice part involve direct contact with pesticides those parts were only administered to pesticide applicators in case of SSIF (n = 171). In LSOF and LSGH due to the specific tasks given to pesticide applicators (only pesticide mixing and spraying), they were not interviewed on all aspects of the pesticide-related attitudes and a question from pesticide-related practices part of the questionnaire (e.g. pesticide label reading, pesticide storage and how to measure pesticides). In these cases, responses were obtained from other farm workers (e.g. storekeeper) and farm managers who were primarily responsible for activities mentioned under this part of the questionnaire resulting in information to be summarized at the farming system level. All other pesticide knowledge and practice-related information was collected from both applicators and re-entry workers working in all of the three farming systems.

The list of used pesticides and an estimate of the total pesticide use in kilograms (kg) + litre (l) per hectare per year (p.h.p.y) were based on records kept at the LSOF and LSGH. Since farmers of SSIF do not formally keep pesticide use record, information about intensively used pesticides, and total pesticide usage was based on verbal responses obtained from individual farmers and farm workers. In order to estimate annual pesticide use the following algorithm was used:

Total pesticide use (kg+l) p.h.p.y = average pesticide active ingredient use per spray (kg ± l) × frequency of spraying per month × spraying months per crop season × crop seasons per year/hectares of land cultivated

DATA ANALYSIS

The Questionnaire data were entered using Epi Data version 3 and analyzed using Stata SE/11.0. Descriptive statistics included arithmetic mean (AM) and standard deviation (SD) for continuous variables and frequency and percentile values for categorical variables in order to compare across farming systems and between exposure groups (applicators versus re-entry workers).

RESULTS

Selected sociodemographic variables of the surveyed population are shown in Table 1. A slightly higher proportion of the total study population was male (54%) with all of the applicators (100%) being male. In the LSGH, the majority of the individuals were female (55%). Most of the surveyed population (52%) had no or only primary level (grades 1–6) of formal education. They were relatively young with a mean age of 27 ± 7 years. Similar educational and age distributions were observed in all farming systems and exposure groups. The average duration of employment of the farm workers was 4 ± 4 years, but was somewhat longer among individuals working in LSOF farms (5 ± 6). Organophosphates were the most intensively used class of pesticides (24%) in all three-farming systems. Organophosphates were used relatively intensively in LSOF (30%) and SSIF (27%) but less in LSGH (8%). Contemporary usage of organochloride pesticides such as dichloro diphenyl trichloroethane (DDT) and Endosulfan were indicated in SSIF. DDT and Endosulfan were reported to be used by, respectively, 25 and 94% of the SSIF farmers within the 12 months period prior to the interview and by 87 and 98% of the SSIF workers since their involvement in pesticide application work, respectively (data not shown).

Modern methods of non-chemical based methods of pest control were used mostly in LSGH and included bio-pesticides (*Trichoderma*, *Bacillus subtilis,* and *Metarizium*) and predators (Phytosiles-subtiles). Integrated Pest Management (IPM) practices were also in progress in these farms. In LSOF, Neem (biopesticide) and manual weeding (cultural method) were used, whereas in SSIF only manual weeding was used as an alternative for chemical pesticides.

The average annual pesticide use per hectare in the three surveyed farming systems was 251 (kg + l) *p.h.p.y* of active ingredients (Table 2). Pesticide use in terms of intensity was the highest in LSGH (623 (kg + l) *p.h.p.y*), followed by SSIF (82 (kg+l) *p.h.p.y*) and was lowest in LSOF (47 (kg + l) *p.h.p.y*).

Only 15% of the farmers and farm workers had received formal training in pesticide hazards. Attaining formal training was more common in LSGH farms (35%) than in the other farming systems. Formal training was also more common among applicators (27%) than among re-entry workers (5%). If we stratify the re-entry workers by gender, none of the 275 females was trained on pesticide hazards (data not shown). The main training provider (69% of all trainings) was the Ethiopian Horticultural Producer and Exporters Association (EHPEA), followed by the employer (19%) and farmers union (11%). No training was given by the health extensions system.

With regard to knowledge of alternatives to chemical pesticides, only 31% of the respondents mentioned at least one of the alternatives with most of the farmers (98%) mentioning manual weeding as an alternative followed by bio-pesticides (10%) and Integrated Pesticide Management (IPM) (8%). None of the farmers or farm workers in the surveyed farming systems mentioned organic farming as an alternative. Modern methods of alternatives to chemical pesticides were mentioned more frequently in LSGH farms and among applicators than in other farming systems and re-entry workers (Table 3).

Only 27% of the surveyed farmers and farm workers in SSIF usually read the pesticide label; only 16% kept their pesticides/left overs in a separate agricultural equipment location or other locked storage; most of them either throw (75%) or bury (16%) empty pesticide containers around the farming field. Most of the SSIF applicators (85%) get their pesticide supplies from private small shops and none of them used scaled measuring equipment (Tables 4 and 5) but LSOF farms either get their supplies from local importers or import pesticides by themselves. In case of the LSGH, special import of chemical pesticides is possible without the formal Ethiopian registration process but with knowledge of the Ethiopian Ministry of Agriculture.

A similar routine procedure is followed in both LSGH and LSOF with reference to pesticide-related handling and management attitude and practices. Before each pesticide mixing/spraying activity, based on prescriptions by a crop protection expert, a

Table 1. Sociodemographic characteristic of the study population

Variables	Total ($n = 601$)		LSOF (n=134)		SSIF ($n = 258$)		LSGH ($n = 209$)		Applicators ($n = 256$)		Re-entry workers ($n = 345$)	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
Sex												
Male	326	54	62	46	171	66	93	45	256	100	70	20
Female	275	46	72	54	87	34	116	55	—		275	80
Educational level												
No formal education	37	6	9	7	17	7	11	5	5	2	32	9
Grades 1–6	278	46	53	40	133	51	91	44	113	44.1	165	48
Grades 7 and 8	159	27	47	35	66	26	46	22	80	31.2	79	23
Grades 9–12	121	20	24	18	42	16	55	26	57	22.3	64	19
Diploma	6	1	—	—	—	—	6	3	1	0.4	5	1
Degree	—		—	—	—	—	—	—	—	—	—	—
	AM	SD	AM	SD	AM	SD	AM	SD	AM	SD	AM	SD
Age (years)	27	7	27	7	27	7	28	7	27	6	28	7
Monthly income (in Ethiopian birr)	1029	577	683	251	1375	685	825	268	1420	664	740	237
Duration of work (years)	4	4	5	6	5	3	4	2	4	2	5	4

Table 2. Chemical pesticide use in surveyed farms

	LSGH				SSIF				LSOF			
	Common name	**Chemical class**	**WHO**	**Type**	**Common name**	**Chemical class**	**WHO**	**Type**	**Common name**	**Chemical class**	**WHO**	**Type**
1.	Thiamethoxam	Neonicotinoid	NL	*I*	Profenofos	Organophosphate	II	*I*	Diazinon	Organophosphate	II	*I*
2.	Imidacloprid	Neonicotinoid	II	*I*	Mancozeb	Dithiocarbamate	U	*F*	Glyphosate	Posponoglycine	III	*H*
3.	Deltamethrin	Pyrethroid	II	*I*	Lambda-cyhalthrin	Pyrethroid	II	*I*	Endosulfan	Organochloride	II	*I*
4.	Abamectin	Bio-origin	NL	*I*	Endosulfan	Organochloride	II	*I*	Mancozeb	Dithiocarbamate	U	*F*
5.	Spinosad	Bio-origin	III	*I*	Dimethoate	Organophosphate	II	*I*	Sulfur	Inorganic	III	*F*
6.	Fosetyl Aluminium	Organophosphate	U	*F*	DDT	Organochloride	II	*I*	Spinosad	Bio-origin	III	*I*
7.	Boscalid	Carboxamide	U	*F*	Metalaxyl	Phenyl amide	II	*F*	Carbosulfan	Carbamate	II	*I*
8.	Metalaxyl	Phenyl amide	II	*F*	Chlorpyrifos	Organophosphate	II	*I*	Chlorpyrifos	Organophosphate	II	*I*
9.	Chlorothalonil	Chloronitrile	U	*F*	Triadimefon	Triazole	II	*F*	Mancozeb + Metalaxyl	Dithiocarbamate + Phenyl amide	U + II	*F*
10.	Carbendazim	Benzimidazole	U	*F*	Mancozeb + Metalaxyl	Dithiocarbamate + phenylamide	U + II	*F*	Profenofos	Organophosphate	II	*I*
11.	Propamocarb hydrochloride	Carbamate	U	*F*	Cymoxanil + Copperoxichloride	Cyano acetamide oxime+ inorganic	II + II	*F*				
12.	Iprodione	Dicarboximide	III	*F*								
	Pesticide use intensity in large-scale closed farms				**Pesticide use intensity in SSIF**				**Pesticide use intensity in LSOF**			
	623 kg+l $year^{-1}$ $hectare^{-1}$				82 kg+l $year^{-1}$ $hectare^{-1}$				47 kg+l $year^{-1}$ $hectare^{-1}$			

NL = not listed; WHO = World health organization acute toxicity hazard class (WHO, 2008), II = moderately hazardous, III = slightly hazardous, U = unlikely to present acute hazard.
Classification by target organism *I*=Insecticides *F*= Fungicides *H*=herbicides.

Table 3. Pesticide-related knowledge of the surveyed population by farming system and exposure type

Variables	Total (n = 601)		LSGH (n = 209)		SSIF (n = 258)		LSOF (n = 134)		Applicators (n = 256)		Re-entry workers (n = 345)	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
1. Thinking pesticides may affect health (n = 601)	573	95	207	99	232	90	134	100	244	95	329	95
2. Presumed main pesticide exposure route (n = 601)												
I do not know	52	9	4	2	40	16	8	6	22	9	30	9
Inhalation	349	58	129	62	143	55	77	58	151	59	198	57
Dermal	92	15	37	18	32	12	23	17	43	17	49	14
Oral	94	16	32	15	39	15	23	17	33	13	61	18
Eye	14	2	7	3	4	2	3	2	7	2	7	2
3. Attaining training (n = 601)	87	15	73	35	11	4	3	2	70	27	17	5
4. Training providing institution (n = 85)												
Agricultural extension service	1	1	—		1	10	—		1	2	—	
Farmers union	9	11	—		9	90	—		9	13	—	
Horticultural association	59	69	59	82	—		—		48	70	11	65
Health extension services	—	—	—		—		—		—		—	
The employer farm	16	19	13	18	—		3	100	10	15	6	35
5. Respondents who mentioned at least one alternative to chemical pesticides (n = 601)	183	31	64	31	93	36	26	19	86	34	97	28

Table 3. *Continued*

Variables	Total ($n = 601$)		LSGH ($n = 209$)		SSIF ($n = 258$)		LSOF ($n = 134$)		Applicators ($n = 256$)		Re-entry workers ($n = 345$)	
	N	%	N	%	N	%	N	%	N	%	N	%
6. Mentioned alternatives to chemical pesticide ($n = 183$)												
Biopesticides	19	10	17	27	1	1	1	4	12	14	7	7
Organic farming	–	–	–	–	–		–		–		–	
Integrated pesticide management	15	8	15	23	–		–		8	9	7	7
Cultural methods	179	98	60	94	93	100	26	100	84	98	95	98

pesticide will be selected from the store. Usually there is consultation of pesticide labels followed by measuring of the pesticides using appropriate scaled measuring equipment by mostly the storekeepers.

In LSGH and LSOF, pesticides are stored in a separate pesticide storage facility. Pesticide containers are usually collected and stored at one place without any rinsing or crushing (Fig. 2) and buried within the farm premises in the case of LSOF. In LSGH farms, empty pesticide containers are collected, rinsed, crushed and incinerated under controlled environmental conditions inside a properly designed incinerator.

Of the farmers and farm workers surveyed, only (10%) used full Personal Protective Equipment (PPE) [i.e. overall, safety shoes, rubber gloves, goggles, and respirator for applicators and rubber gloves, apron, and safety shoes for re-entry workers (Table 5)]. In LSGH these totaled 26% of the workers, but 5% in LSOF and none in case of SSIF (Fig. 3). In contrast, 13 and 7% of the re-entry and applications workers use full PPE, respectively. None of the applicators and the re-entry workers (who were all females) in surveyed SSIF farms used full PPE (data not shown). Of the farmers and farmworkers, respectively, 84 and 32% washed their hands and took a bath or shower after work. These hygienic practices were observed more frequently among applicators than among re-entry workers (91 and 44% versus 78 and 23%) (Table 5).

DISCUSSION

In our study, a relatively low level of pesticide-related KAP in all surveyed farming systems and exposure groups were observed. Use of organochlorides (DDT and Endosulfan) on vegetables albeit illegal was reported in SSIF. Issues of poor attainment of formal pesticide-related training (especially among re-entry workers), poor pesticide management, disposal, and limited use of complete PPEs were found in all three surveys farming systems but were particularly poor in SSIF. Though pesticide management and disposal is exemplary in the LSGH, the empty pesticide compilation and burial practices in the LSOF remain hazardous practices.

This study showed an increase in pesticide use, as compared to previous estimates in different farming systems in horticultural farms in Ethiopia. Which appeared to be 13-fold in case for SSIF, from 4 to 8 (kg + l) /ha^{-1} year^{-1} in 2008 (Deribe, 2008) and a 6-fold

Table 4. Pesticide-related attitudes in surveyed applicators in small-scale farmers and farm workers (n = 171[a])

Study variables	N	%
1. Pesticide label reading (n = 171)	46	27
2. Main reason for not usually reading the level (n = 125)		
Not important	56	45
Another language	2	2
Once I read	45	36
No time to read	22	17
3. Storage of pesticides/pesticide leftovers (n = 171)		
I do not store	1	1
Separate agricultural equipment store	27	16
Bush around the home	10	6
Under the bed	66	38
Inside a kitchen	1	1
Hanging in the ceiling/wall	39	22
Locked box	27	16
4. Empty container management (n = 171)		
Throw it away in the farm vicinity	128	75
Use for domestic purpose	2	1
Bury	28	16
Burnt	8	5
Collect and sold	5	3
5. Pesticide source for agricultural use (n = 171)		
Public	24	14
Private small shops	145	85
Private importer	2	1
Self-import	—	

[a]The total number is smaller here because the relevant information was collected at a farm level in other farming systems.

increase in the case of LSOF from 8(kg + l) ha^{-1} year^{-1} in 2006 (Environmental and Social Assessments International, 2006). Even though no previous estimates of pesticide use are available for the LSGH, the present study indicated very high use of pesticides in terms of intensity (623 (kg + l) ha^{-1} year^{-1} in LSGH as compared to other farming systems. The increased use of pesticides in combination with the general poor pesticide-related handling and management practices found in this study could potentially lead to serious occupational and environmental risks.

Agricultural use of DDT was reported in SSIF. This pesticide is banned for agricultural use under the Stockholm convention of persistent organic chemicals

Table 5. Pesticide-related practices in surveyed population by farm and exposure type

Variables	Total ($n = 601$)		LSGH ($n = 209$)		SSIF ($n = 258$)		LSOF ($n = 134$)		Applicators ($n = 256$)		Re-entry workers ($n = 345$)	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
1. Complete use of PPE ($n = 601$)	62	10	55	26	_		7	5	18	7	44	13
Apron	144	24	117	56	9	4	18	13	11	4	133	39
Safety shoes	143	24	103	49	16	6	24	18	92	64	51	15
Rubber gloves	191	32	168	80	1	0.4	22	16	67	26	124	36
Goggles	32	5	21	10	—		11	8	24	9	8	2
Overall	108	18	77	37	—		31	23	80	31	28	8
Respirator	59	10	48	23	—		11	8	50	20	9	3
Handkerchiefs	2	4	—		23	9	—		23	9	—	
Head cover	27	5	—		18	7	9	7	18	7	9	3
2. Main reason for not using complete PPE ($n = 539$)												
Not important	105	19	5	3.2	71	28	29	23	42	18	63	21
Too expensive	26	5	2	1.3	23	9	1	1	18	7	8	3
Not provided	200	37	111	72.1	26	10	63	50	42	18	158	52
Uncomfortable	62	12	33	21.4	13	5	16	12	24	10	38	13
Ignorance/no much attention	146	27	3	2	125	48	18	14	112	47	34	11
3. Protective hygienic measures												
Wash hand after work ($n = 601$)	502	84	162	77	220	85	120	90	233	91	269	78
Bath after work ($n = 601$)	190	32	68	32	64	25	58	43	112	44	78	23

Table 5. *Continued*

Variables	Total (n = 601)		LSGH (n = 209)		SSIF (n = 258)		LSOF (n = 134)		Applicators (n = 256)		Re-entry workers (n = 345)	
	N	%	*N*	%	*N*	%	*N*	%	*N*	%	*N*	%
4. How to measure pesticides (n = 171[a])												
Properly scaled equipment	—		—		—		—		—		—	
Household equipment	—		—		—		—		40	23	—	
Approximation	—		—		—		—		53	31	—	
Pesticide container cap	—		—		—		—		78	46	—	

[a]The total number is smaller here because the relevant information was collected at individual levels only from small scale applicators but at a farm level in other farming systems.

and signed by Ethiopia. Use of DDT is only allowed in indoor residual spraying for malaria control (Biscoe *et al.*, 2005) but farmers in this study reported use on food crops. The present study therefore upholds the continuous environmental and occupational risk of DDT in Ethiopia. In addition, the extensive use of Endosulfan on horticultural food crops in SSIF is worrisome since it is not registered for use on vegetables and can only be restrictively used on for instance cotton in LSOF.

Generally, receiving pesticide-related training is very low in surveyed farmers and farm workers except among a few farm workers, who were applicators and mostly employed by the LSGH. This is due to an availability of a relatively vigilant institution like the Ethiopian Horticultural Producer and Exporters Association (EHPEA) that provides training to farm workers working in its members' green houses. However, in the case of LSOF there is no permanent training provision team/staff. In addition, in the case of SSIF, little attention by the local agricultural extension and farmers cooperatives is given to train farmers on safe use of pesticide (except guiding them on agronomic practices) and no attention at all by local health extension service or other institutions like the local labor and social affair or environmental office. These are likely reasons for the very low level of pesticide-related training in those farming systems. Similar studies in developing countries have indicated comparable poor attendance of pesticide-related trainings; for instance only 16% of surveyed female farmers in South Africa attained any formal training (Naidoo *et al.*, 2010) and almost all (98%) of the respondents of a survey in Egypt indicated they did not receive any training (Ibitayo, 2006). Attendance of pesticide-related hazard training is vital to be acquainted with safe use of pesticides such as pesticide label reading, right disposal of empty pesticide containers, use of complete and appropriate personal protection and hygienic practices after work. Therefore, absence/low level of training attendance in this survey suggests a high potential for occupational and environmental risks to occur.

In our study, small proportion of farmers and farm workers knew at least one of the modern methods of non-chemical pest control. Similar results were reported for Egypt where 59 and 20% of the respondents indicated they were 'not sure' and 'do not believe'

Figure 2 Disposal of discarded empty pesticide containers collected in one of the large scale open farms.

Figure 3 Pesticide mixing practices in small scale irrigated areas.

in alternatives to chemical pesticide (Ibitayo, 2006) and 84% did not see an alternative for chemical pesticide use (Stadlinger *et al.*, 2011).

Only about a quarter of the SSIF workers usually read the pesticide label and none of them use scaled measuring equipment. Reading the label and using scaled equipment are important as to adhere to the recommended dose of pesticides, which can result in very high exposures if used over the recommended amount or might result in pesticide resistance if used under the recommended utilization. Other studies showed similar figures with only 2 and 18% of the surveyed small-scale farmers in Tanzania and South Africa usually reading pesticide levels (Naidoo *et al.*, 2010; Ngowi, 2003).

Poor pesticide-related management (in small-scale farms) and disposal (in small scale and LSOF) were seen in this study. Similar results of improper disposal of pesticide containers (burning, burying, or throwing) were reported in Egyptian farmers (Ibitayo, 2006). In addition, a study in China reported, discarding pesticide containers in the environment (soil or water) or with other trash by a majority (52%) of the farmers (Zhang and Lu, 2007). Improper management of pesticides was reported in a study in Kenya where more than half of the interviewed farmers stored pesticides in places like under the bed, in the bush or in the latrine (Ohayo-Mitoko, 1997). Also a study in Tanzania reported storage of pesticides with in residential home, often in rooms used by a number of family members by 81% of the respondents (Lekei *et al.*, 2014). Another study from China reported improper storage of pesticides in bedrooms, granary, and kitchens (Zhang and Lu, 2007). The overall improper pesticide management and disposal of empty containers can pose an environmental risk in surveyed farming areas and health risks to the general population.

Though most of the pesticides used by the surveyed greenhouse farms (Table 2) are still registered for use in European Union, the continued importation of pesticides by all LSGH in Ethiopia without formal registration process that includes occupational and environmental risk assessment may have its own negative impact on health of the work force and environmental sustainability. The majority of the applicators in SSIF get pesticide supplies from private small shops, in which only 20% the retailers had a formal education about pesticides (Belay *et al.*, 2014). Consequently, those retailers are not able to properly advice farmers on proper use, management, and disposal which may lead to improper use and handling of pesticides resulting in increased occupational and environmental risks.

Only a small proportion of the surveyed farmers and farm workers, pesticide applicators, and re-entry workers utilized full PPE. Except for the use of some sort of head covering and handkerchiefs, there was no complete PPE use by any of applicators in SSIF, mostly exposing their face, hands, palms and their fingers (Fig. 3). Most of the pesticide applicators employing some kind of PPE do not usually use PPE like eye goggles (5%) and respirators (10%). Anecdotally and witnessed in the field even if personal protection was used it was often removed minutes after the start of application of pesticides, since applicators were complaining about not being able to see (goggles) or breathe properly (respirator). Moreover it was observed that most of the applicators using some kind of personal protection were not using it while mixing/loading concentrated pesticides which are known to carry a higher risk of exposure than diluted pesticides (Macfarlane *et al.*, 2013). Previous surveys in LSOF in Ethiopia indicated personal protection was not always provided and not always fit for use (Mekonnen and Agonafer, 2002). Other studies in developing countries report similar results, no personal protection use by more than half of the farmers during mixing or application of pesticides in Tanzania (Stadlinger *et al.*, 2011). Using personal protection was also not common practice during pesticide application in Brazil (Recena *et al.*, 2006). In addition, a study in Pakistan indicated no use of basic protective equipment during pesticide handling and application (Khan *et al.*, 2010). In this study, the absence of personal protection use by most farm workers and discontinued usage of it while performing pesticide-related tasks suggest that assumed protection factors in the regulatory framework do not hold in practice and could lead to potential health risks.

Only a third of farmers and farm workers usually took a bath/shower after work, and less than half of the pesticide applicators usually took a bath/shower after pesticide spraying. Mekonnen *et al.* (2002) reported similar results in which many of the pesticide applicators did not take a shower regularly after work in LSOF in Ethiopia. During our field survey, it was observed that there was a general absence of washing facilities for those farm workers in the SSIF and LSOF, so in order to take a shower farmers and farm workers had to go back to their home or have to use the water from the irrigation schemes or nearby lake. Washing facilities were however present in the LSGH farms even though most farm workers, particularly re-entry workers, were not using them. The poor pesticide-related hygienic practice in this survey could lead to continued pesticide exposure after work resulting in potential increased health risks.

CONCLUSIONS

This systematic survey has indicated a significant increase in use of chemical pesticides in the last decade in farming systems in Ethiopia. Unfortunately, the attitudes and practices among farmers and farm workers in the three farming systems surveyed in Ethiopia are poor. The most likely reasons for this unsafe use of pesticides of the surveyed population were: lack of formal training on pesticide-related occupational and environmental hazards; the absence of a responsible institution particularly in SSIF and LSOF for training provision; and the continued illegitimate usages of organochlorides particularly DDT on food crops in SSIF. Altogether, the data may point towards the possibility for significant occupational and environmental risks related to the commercial use of pesticides. The present situation needs urgent collaborative actions in order to expand some of the important affirmative actions of good agricultural practice that have been initiated by LSGH owners (Ethiopian Horticultural Producer and Exporters Association) to small scale and LSOF including provision of formal training to all farmers and farm workers. Training should be given not only to pesticide applicators but also to re-entry workers particularly female once. In addition, contextual enforcement of the available occupational and environmental proclamations and the development of Integrated Pesticide Management (IPM) practices should be taught. Those suggested measures must be implemented in ways that can address institutional differences in various farming systems existing at present in Ethiopia.

DECLARATION

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