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Research Article

Practices and Knowledge of Smallholder Farmers Towards Safe Pesticide Management in East Gojjam Zone, Northwest Ethiopia

Abebaw Adamu*, Anduamlak Assaye

Ethiopian Institute of Agricultural Research (EIAR), Debre Markos Agricultural Research Center (DMARC), Agricultural Extension Research Department, Debre Markos, Ethiopia

Abstract

In recent years, safe pesticide management has become increasingly important. Thus the research was aimed to evaluate the current state of pesticide management practices and farmers knowledge. The study deployed a multistage sampling technique to select participant districts and the respondents. About 268 sample respondents were drawn from six districts of East Gojjam zone. The results revealed that the majority of the farmers (69.45%) store their pesticides in their houses that they perceive anybody can't be reached. Farmers were found to have poor practices of using face masks, overalls, goggles, and gloves. Farmers frequently engaged in good practices of washing and calibrating spraying machines. Around 57.22%, 41.9%, and 38.9% of farmers visit their freshly sprayed fields within 24 hours of spraying insecticides, herbicides, and fungicides, respectively without using personal protective equipment. Farmers demonstrated proficiency in several hygienic practices including taking a bath, changing clothes, and washing cloths immediately after spraying. Participant farmers experienced various health symptoms after spraying pesticides. The majority of the farmers were cognizant on exposure routs of pesticides. However, they didn't understand the intended pictogram messages from pesticide containers. The study demonstrated that improper pesticide management had an impact on both the environment and farmers' health. Thus, there is a need to improve farmers' knowledge and skills by offering regular awareness-raising training on safe pesticide management techniques.

Keywords

East Gojjam, Health Symptoms, Knowledge, Pesticides, Practices, Safe Use

1. Introduction

During the mid-twentieth century, the green revolution initiatives brought about global crop yield advancement through the use of high-yielding seed varieties, chemical fertilizers, and pesticides. This model has controlled various pests and increased global food grains, particularly in developing countries.

Pesticides are a key agricultural input that can help to protect crops from weeds, insects, bacteria, fungi, and rodents [1]. Forty per-cent of the world's agricultural produce loss came from crop diseases, weeds, and insects [2]. Despite its significant impact on the environment and human health, farmers worldwide consider pesticides as an essential

*Corresponding author: abebawadamu@gmail.com (Abebaw Adamu)

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technology to feed the growing human population [3]. Without the use of pesticides, it would be impossible to produce crops, vegetables and other fruits and eventually difficult to feed the growing population.

Although pesticides are meant to target and eliminate specific pests, they can also harm non target plants, microorganisms, and animals. There has been growing concern about the excessive use of environmentally persistent pesticides in agriculture. These pesticides pose risks to humans, livestock, wildlife, and the environment. Pesticides have a negative impact on the environment by contaminating soil, water, air, and non-target plants and animals, which can reduce biodiversity and, in some cases, crop yields [4] and also harm beneficial pollinating insects and animals such as bees and birds.

Global pesticide use has continued to increase in the past decades in terms of total volume and amount applied per hectare of cropland [5]. Unfortunately, only limited amount of pesticides came in contact or ingested to eliminate or control the target pests. The vast amount of the applied pesticides is dispersed and degraded to the environment due to spray drift, abiotic, biotic and other factors. Due to diverse and complex set of factors in developing nations, unwise pesticide application and management practices is believed to be at its higher level. Today, it is well known that exposure to pesticides can result in both acute and chronic health problems [6]. Studies have indicated a link between pesticides and various forms of cancer diseases [7]. These harmful chemicals can enter the body through the respiratory tract, skin, and digestive system when used in agriculture [8, 9].

Although pesticide use has been prevalent in Ethiopia for over six decades [10], it continues to increase. Unfortunately, poor management practices and excessive use in the East Gojjam zone have led to a decline in biodiversity and pose a threat to future agricultural productivity [11]. There is little knowledge on the status, practices, and perceptions of smallholder farmers towards safe pesticide use in the study area. The research aims to evaluate the current state of pesticide management practices and farmers` knowledge on safe pesticide use.

2. Methods

2.1. Description of the Study Area

The study area East Gojjam Zone is located in the Amhara Regional State, north-western part of Ethiopia. The zone covers different topographic features with elevation ranging from 800 to 4200 meters above sea level (masl). The highest mountain, Choke, with an elevation of 4100 masl is found in this zone. The zone topographic features traditionally include 67.3% flat landscape while 7.8 and 24.9% are mountainous and gorge landscapes, respectively.

East Gojjam zone is traditionally categorized into four major agro-ecological zones; *Kolla* which accounts for 5.45% of the total zone coverage; covers 80.55% of the total zone area; *Dega* accounts for 11.9% of zone coverage; and *Wurich* accounts for 2.1% total area coverage in the zone. *Weyina Dega* agro-ecological zone is the major potential and surplus producing area of the zone. The rainfall pattern is mainly a unimodal type where the average annual rainfall varies from 900 to 1800 mm while there is a short rainy season (*Belg*) during February and March in the highland of (*Dega*) agro-ecology. The average temperature of the zone ranges from minimum 7.5 ^{o}C to high 27 ^{o}C. The major soil types in order of importance include Vertisol (black soil), red, and grey soils.

2.2. Sampling and Sampling Techniques

The research was carried out during the 2022 cropping season. A multistage sampling technique was deployed to select participant districts as well as respondents. At the first stage, Gozamin, Debre Elias, Sinan, Debay Tilatgin, Enemay and Enarge Enawga districts were selected purposively based on pesticide use potential and practices. At the second stage, one kebele was selected randomly from each five districts. Whereas, two kebeles were selected from Gozamin district due to prevalence of higher population compared to other sample districts. Finally, a total of 268 household samples were drawn randomly. Overall, 256 male-headed and 12 female-headed households were selected using a probability proportional sample to size method for each kebele.

Both primary and secondary data sources were used. The primary data were collected through household interview schedules, group discussions, key informant interviews, and field observations on pesticide use practices of farmers. In addition, the secondary data were collected from different journal articles, official reports, books and zone level annual reports.

2.3. Method of Data Analysis

A descriptive statistics such as frequency, percentage, mean and standard deviation were used for analysis of household level safe pesticides use practices, equipment management methods and disposal of pesticide left overs and pesticide containers. Similarly, a three-point Likert-type scale (1 for “never”, 2 for “sometimes” and 3 for “always”) was used to measure the frequency of households' pesticide use practices and sum the frequency of the Likert scale results. The sum of frequency values was used to categorize pesticide use practices based on the mean value. The mean value greater than or equal to 2 indicates best practices frequently used by households, while mean values less than 2 indicates practices not used by households. Statements measuring bad and good practices were categorized based on whether they were scientifically acceptable or unacceptable. Mean values greater than or equal to 2 were considered unacceptable if households practiced them frequently. Whereas, mean values less than 2 indicates bad practices which not used by households.

To evaluate farmers understanding of pesticide pictograms, visible and larger-sized commonly used pictures were displayed in front of sample households. For each pictogram,

if farmers reply the intended message correctly one point and, if not zero point was given. The qualitative data collected from group discussion, key informant interview and personal observation was narrated in each thematic area.

3. Results and Discussion

3.1. Household Characteristics of the Respondents

The majority of respondents (95.52%) were male-headed, whereas the remaining (4.48%) were female-headed households. The mean age, pesticide use experience, and farming experience of the sample respondents were 43.78, 11.05, and 23.62 years, respectively (Table 1). Regarding the educational status of the respondents, 67.90% were unable to attend the formal school accordingly 27.20% were able to read and write in different informal ways, 28.40% received primary school education, and 3.70% received secondary school education (Table 2).

Table 1. *Household characteristics of respondents.*

Variables	n	Minimum	Maximum	Mean	SD
Age of household head (year)	268	21	77	43.78	11.505
Farming experience of HHH (year)	268	2	55	23.62	11.384
Pesticide use experience of HHH (year)	268	2	35	11.05	7.061

Table 2. *Educational background of the respondents.*

Educational Status	n	Percent	Commutative percent
Illiterate	109	40.70	40.70
Able to read and write	73	27.20	67.90
Primary school (grade 1-8)	76	28.40	96.30
Secondary school (grade 9-12)	10	3.70	100.00
Total	268	100.00	

3.2. Pesticide Storage Practices

Nearly two third of the respondent farmers (69.45%) store their pesticides in the house that they perceived anybody can't be reached (Figure 1). Only 12.7% of participant farmers store pesticides in a separate, locked place. Farmers in the study area stored the sealed, unlabelled, partially full, or diluted leftover pesticides in their house and kitchen without taking into account the side effects. Similar findings were reported by Yawson, about 58.20% of Barbadian farmers mostly stored pesticides in their homes [12]. Another study done by Ndayambaja *et al*. indicated that Rwandan rice producer farmers stored pesticides and empty pesticide cans in their homes and kitchens [13]. Similar pesticide storage practices in Ethiopia have also been reported. In Northwest Ethiopia, 60.9% of farmers keep pesticides in their living houses [14]. Studies also reported that most Ethiopian farmers store pesticides in their bedrooms, living rooms, and kitchens [15, 16]. Pesticides should always be stored kept away from livestock and children, separated from food and drinks, and locked properly [17]. Keeping pesticides in the home and kitchen can lead to an increase in food and water contamination due to vapours, dust, and spills.

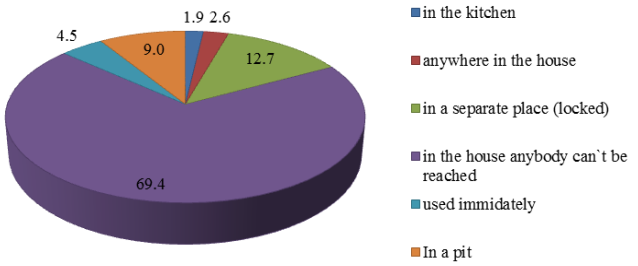

Figure 1. *Pesticide storage practices of farmers.*

3.3. Personal Protective Equipment Use Practices

Farmers have implemented good practices such as using long sleeved shirts, plastic boots and hats during mixing and spraying pesticides (Table 3). The farmers in the study area were found to have poor practices of using some protective equipment during mixing and spraying of pesticides. Specifically, they were not often using face masks, overalls, goggles, and gloves during mixing and spaying as well as washing spraying machines (Table 3).

Table 3. *PPE usage practices of farmers.*

Practice statements	n	Min	Max	Mean	SD
Using hats during mixing and spraying of pesticides	265	1	3	2.14	.881
Using face mask during mixing and spraying of pesticides	265	1	3	1.90	.867
Using overall during mixing and spraying of pesticides	264	1	3	1.76	.898
Using long sleeved shirts during mixing and spraying of pesticides	265	1	3	2.51	.692
Using goggles during mixing and spraying of pesticides	265	1	3	1.08	.386
Using gloves during mixing and spraying of pesticides	265	1	3	1.36	.746
Using plastic boots during mixing and spraying of pesticides	265	1	3	2.44	.829

It is important for farmers to use this personal protective equipment (PPE) to stay safe from pesticide exposures. It is widely known that pesticides can enter the human body through three ways: ingestion, inhalation, and skin contact when handling pesticides without PPE. Therefore, it is crucial for farmers to prioritize the use of PPE and ensure that they are using it properly to minimize the risk of pesticide exposures.

Even though farmers have good practices on using hats, long-sleeved shirts, and plastic boots; during the field observation and key informant interviews, it was found that some of the abovementioned protective equipment components were pesticide absorbents and were being used to keep the farmers warm and to protect dews during spraying. It is unfortunate that these essential PPE items are not readily available in pesticide stores. While we were observing farmers in the field, we noticed that they sprayed their crops wearing their normal old clothes by covering their mouths and noses with towels.

This research finding is consistent with a study done by Sarkar *et al*. in developing countries, the use of PPE is highly problematic and it is frequently unavailable [4]. Studies indicated that Ghanaian farmers lacked access to recommended protective equipment like overall, coats, nose masks, boots, and gloves [18]. Almost all Rwandan rice producer farmers wear their normal cloths during spraying of pesticides [13]. Similarly, Moroccan farmers never used waterproof gloves, hats, and masks when handling pesticides [19]. More than 90% of small-scale vegetable farmers in the Lake Ziway area of Ethiopia did not use personal protective equipment when using pesticides [20].

3.4. Spraying Machine Management Practices

According to the survey result, respondents frequently engaged in good practices such as washing the spraying machine before spraying, washing the spraying machine after spraying and calibrating spraying machines before use (Table 4).

Table 4. *Spraying machine management practices of farmers.*

Practice statements	n	Min	Max	Mean	SD
Washing back pack sprayer before spraying	265	1	3	2.56	.747
Washing back pack sprayer after spraying	265	1	3	2.52	.774
Back pack sprayer calibration before spraying	265	1	3	2.50	.739

After completing the spraying operation, it is important for applicators to clean the spraying machine before the next use. Failure to do so may result in contamination, which can cause unintended damage to crops. The backpack spraying equipment is the most popular pesticide application tool in the study area. To ensure that the pesticide spray is being delivered accurately, it is important to calibrate the spraying machine. Different crop types require specific nozzle adjustments to effectively control pests. Clogging of nozzles can be caused by dirty water, which can hinder the process. Therefore, it is important for pesticide applicators to clean the spraying machines with strong detergents and partially fill them with clean water to check for uniformity before mixing pesticides.

According to Brewer International, poorly calibrated nozzles can lead to over application of pesticides which is wasteful, costly, and potentially harmful to the environment [21]. Unlike over application of pesticides, under-application of pesticides also, leads to poor pest control and repetitive pesticide application. Farmers in the study area frequently calibrate the spraying machine before they commence spraying pesticides (Table 4). Participant farmers in the study area reported that they know the technique and usually calibrated the nozzles with water until a uniform spray pattern is achieved. The result of this study is in line with the study finding of Adamu & Abebe in Basoliben district wheat producer farmers were frequently calibrate their spraying machines before starting the spraying [22].

3.5. Pesticide Dose Practices

In the study area respondent farmers use three common pesticide types (herbicides, insecticides, and fungicides) to control weeds, insects and fungal diseases, respectively. There is a knowledge gap in farmers' practices and understanding of using pesticide dose. Respondent farmers also use different pesticide doses that vary from manufacturers' recommendations.

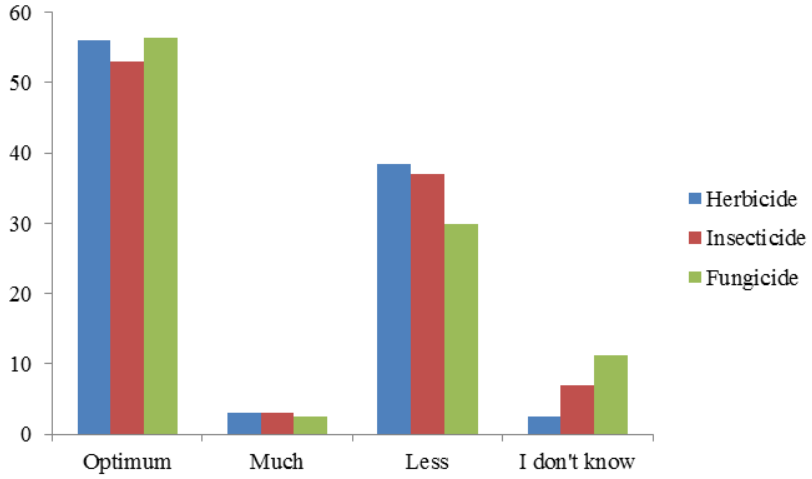

Figure 2. *Pesticide dose practices of farmers.*

According to the survey result, 57.50% of farmers stated that the doses of pesticides they use are ineffective even when they follow the recommended usage instructions (Figure 2). The survey result also revealed that 38.40%, 36.60%, and 29.90% of the farmers used over the manufacturer's recommended dose for herbicides, insecticides, and fungicides, respectively (Figure 2). Farmers who practice under-dosage or over-dosage are tend to increase crop pests' resistance. It is interesting to note that within the past five years; only 24.60% of farmers in the study area have received limited training on pesticide management.

3.6. Practice of Using Unlabelled and Fumigant Insecticides

It is important for users to refer pesticide labels information on their safe and appropriate use. These labels are especially helpful for farmers who may forget verbal instructions given by development agents and pesticide dealers. However, farmers might not have access to this crucial information if a pesticide is unlabelled and taken out of its original container. It's also important to note that all pesticides have the potential to be very toxic before being mixed with water, which can pose health risks to farmers.

According to the survey results, the majority of the farmers (54.50%) claimed that they never used unlabelled pesticides however 26.50% farmers sometimes used them, and the remaining farmers always used unlabelled pesticides. Most farmers (67.20%) reported that their main challenge in the area is unavailability of small and labelled pesticides for their fragmented land, despite claiming to only use labelled pesticides.

The local government frequently supervises pesticide dealers to prevent the sale of unlabelled pesticides, but some farmers still share unlabelled pesticides with their neighbours and fellow farmers to apply to their fragmented lands. As a result, it is difficult to generalize all farmers are using only labelled pesticides. According to a study done by Gadissa *et al*. in the East Wellega zone of the Gudeya Bila district, 63.50% of farmers purchase and use unlabelled pesticides [23]. In Rwanda and Burundi vendors sold pesticides by unlabelled containers [24].

The majority of participant farmers (67.43%) use fumigant pesticides to their local storages (made of mud) in the house with family members to control storage pests. Similarly, 18.29% of farmers use fumigant pesticides in the house with family members in poly sacks, including used fertilizer bags. Only 6.86% of farmers use fumigant pesticides in a separate, dedicated room (Figure 3).

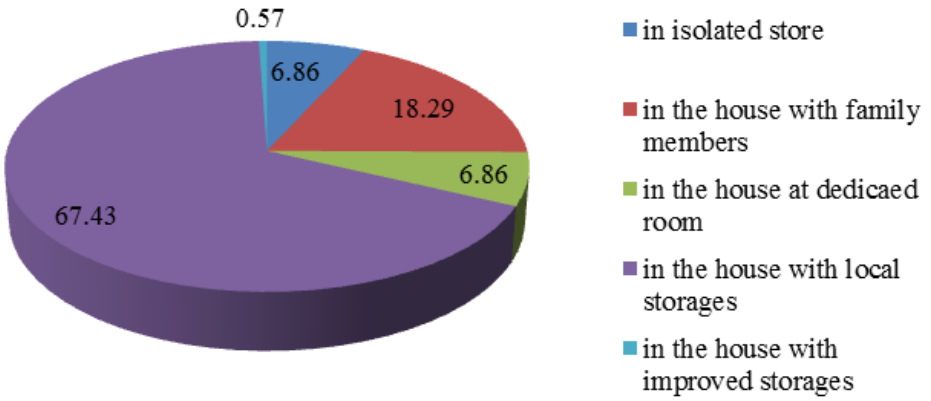

Figure 3. *Fumigant insecticide use practices.*

Farmers in the study area didn't use modern storage structures. They widely used traditional grain stores, such as above-ground bins made of mud, "*gotera*," and poly bags (used fertilizer bags). These grain storage materials are susceptible to grain pests. In the study area, the farmers used different fumigant pesticides to protect and control the grain storage pests. *Celphos* is the commonest storage fumigant insecticide in the study area.

Fumigant pesticides are found under insecticides category. These categories of pesticides are considered to be the most toxic when compared with fungicides and herbicides on the toxicity list [2]. According to Bauer, fumigants are highly toxic to most living things, including humans. Inhalation of even small amounts of some fumigants can be fatal [25].

To be effective, fumigants must be used in enclosed and tightly sealed spaces. Unfortunately, most of the farmers apply fumigant pesticides in their homes, using local storage options without considering the potential hazardous effects of pesticides. As a result, these storage materials are inefficient and the family members are contaminated by the fumigants.

3.7. Disposal Practices of Pesticide Leftovers and Containers

The survey result showed that farmers didn't practice disposing of pesticides leftovers by burying and by emptying tanks/applying repeatedly. They usually kept in the tank for future use. Similarly, respondent farmers didn't dispose pesticide containers by burying, burning, by throwing away in the field, reusing them for household chores or selling them (Table 5). They usually collect and store empty pesticide containers outside homes and kitchens. In our observation, few famers collect and sell empty plastic pesticide containers to local collectors for recycling. The finding is consistent with the previous study of Adamu & Abebe in Basoliben district; farmers didn't practice disposing of pesticide containers by burying, burning, throwing, reusing for household chores, or selling [22].

Table 5. *Disposal practice of pesticide leftovers and containers.*

Practice statements	n	Min	Max	Mean	SD
Disposing pesticides leftovers by burying	267	1	3	1.85	.886
Disposing pesticides leftovers by emptying tanks/ applying repeatedly	267	1	3	1.84	.824
Disposing pesticides container by burying	267	1	3	1.92	.933

Practice statements	n	Min	Max	Mean	SD
Disposing pesticides container by burning	267	1	3	1.49	.748
Disposing pesticides container by throwing	267	1	3	1.40	.757
Reusing pesticides container for household chores (oil, water, food)	267	1	3	1.36	.635
Disposing pesticides container by selling	267	1	3	1.28	.625

3.8. Restricted Entry Interval (REI) and Hygienic Practices

A restricted entry interval is the amount of time which agricultural workers are restricted to enter a treated field after a pesticide is applied. To ensure the safety of farmers and livestock, pesticide manufacturers included safety information on their packaging, such as leaflets or labels. These leaflets indicate how long farmers should wait before entering a treated field without wearing PPE. Even though obeying the re-entry period is an important aspect of protecting farmers from pesticide drifts in the study area, they adhere to varying re-entry periods after the spraying operation is completed.

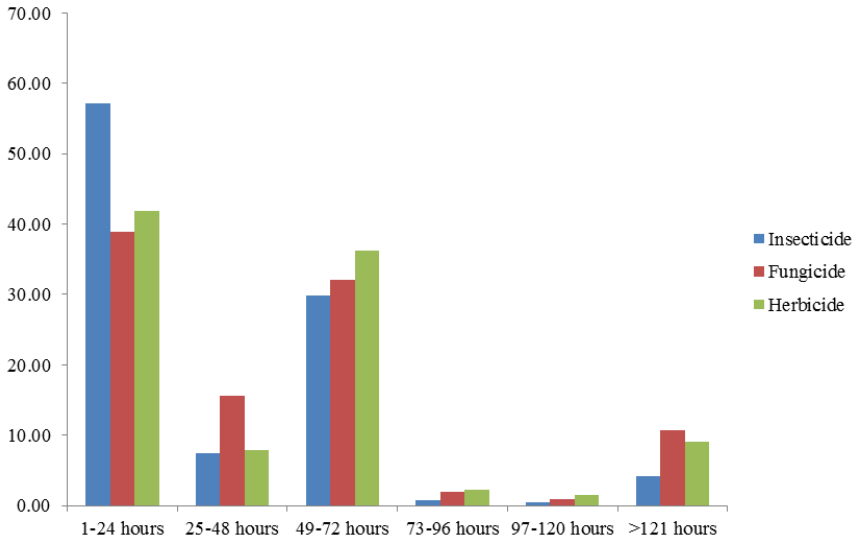

Figure 4. *Farmers practice on restricted entry interval.*

The survey result revealed that 57.22%, 41.90%, and 38.90% of farmers visit their fields within 24 hours of spraying insecticides, herbicides, and fungicides, respectively, without following the manufacturer's recommended re-entry intervals (Figure 4). In addition, 29.89%, 36.3%, and 32.10% of farmers visit their fields without wearing PPE at intervals of 49 to 72 hours after spraying insecticides, herbicides, and fungicides, respectively.

The finding is in line with PAN Asia Pacific that the majority of farmers (92%) entered freshly sprayed fields within the first three days after spraying to complete urgent agricultural tasks [26]. The situation was also true in the Philippines, where 88% of respondents reported entering freshly sprayed fields. Since pesticides remain active for two to three days, this practice will affect farmer's health. A similar finding was reported by Afata *et al.*; in Western Ethiopia, Kellem Wellega, zone, 73.10% of farmers enter freshly sprayed farmland without wearing PPE [27]. Since pesticides' detrimental effects are not instantaneous, farmers failed to notice and respect the importance of the re-entry period. The majority of farmers (71.20%) in Hawassa's rural kebeles believe that visiting the treated field without protective equipment will not seriously impair their health [16].

Farmers demonstrated proficiency in several hygienic practices including changing clothes immediately after spraying, washing clothes immediately after spraying and bathing immediately after spraying (Table 6).

Table 6. *Farmers hygienic practices.*

Practice statements	n	Min	Max	Mean	SD
Bathing immediately after finishing spraying operation	265	1	3	2.23	.820
Changing cloths immediately after finishing spraying operation	265	1	3	2.61	.642
Washing cloths after spraying operation	265	1	3	2.75	.540

Pesticide applicators are routinely contaminated with pesticides due to splashing, spilling, and drifts. It is important to wash their bodies and change clothes immediately after the spraying operation is completed. In this regard, farmers in the study area had good hygienic practices (Table 6). This finding is in line with the study conducted by Endalew *et al.* in Bahir Dar area, about 72.70% of the floriculture workers wash their bodies regularly and also 56.70 % of floriculture workers change their clothes immediately after spraying [28]. Likewise, in Fogera district, 43.50% of farmers claimed that they usually change their clothes and 40.70% of the farmers took a shower after spraying pesticides [29].

In the study area, farmers typically use their normal old clothes for spraying activities. Farmers claimed that they usually wash their spraying clothes separately after the operation is completed. The finding is also consistent with Khadda *et al.* study in Morocco; most of the farmers are familiar with cleaning their clothes after applying pesticides [19].

3.9. Effects of Pesticides on Human Health and the Environment

The survey result revealed that, more than half of the respondent farmers were experienced various health symptoms after spraying pesticides including excessive salivation, body weakness, eye irritation, loss of appetite, nausea, excessive sweating, headache, skin irritation, and breathing difficulties (Figure 5). Similar findings were also reported by Kangkhetkron & Juntarawijit the Thai farmers experienced acute health symptoms after handling pesticides [30]. Rwandan rice farmers also reported various health symptoms, including itching of the skin, headaches, difficulty breathing, and nausea or stomach upset during or after spraying pesticides [13]. Excessive salivation, body weakness, eye irritation, loss of appetite, nausea, excessive sweating, headache, and skin irritation were the most prevalent health symptoms reported by small-scale vegetable farmers in the Lake Ziway area [20]. In Kellem Wellega of Ethiopia, smallholder farmers experienced health symptoms such as headaches, skin irritation, inhalation, and skin irritation from pesticide exposure due to a number of factors [27].

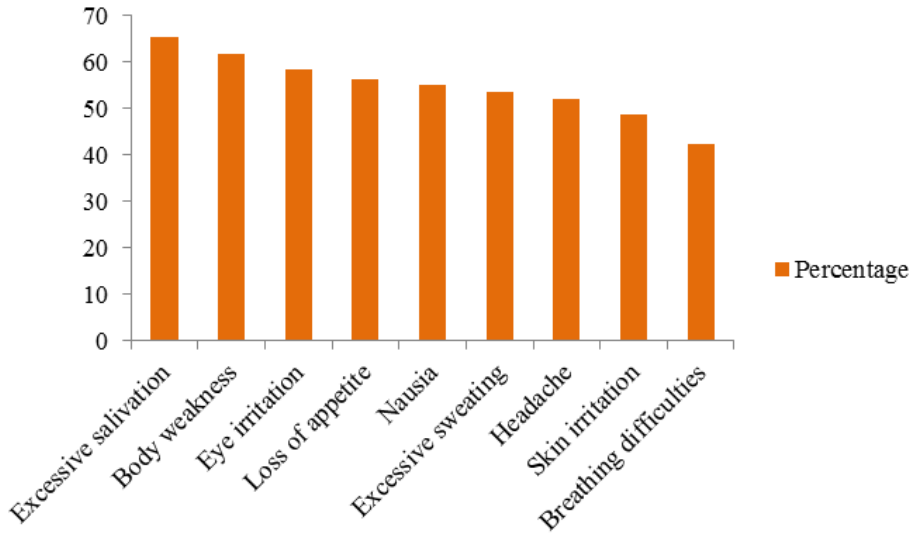

Figure 5. *Self-reported health symptoms.*

It is well known that the unwise application of different pesticides in the agricultural production system increases

concerns about environmental health. During the study, 64.60%, 69.00%, and 79.10% of the respondents replied that, an increasing of weed, insect infestation, and crop diseases were observed as result of frequent application of pesticides (Figure 6). Majority of the respondents, 85.80%, 74.60% and 47.80% acknowledged that, over the past five years, there had been declines in the populations of bees, other pollinating insects, and birds, respectively (Figure 6).

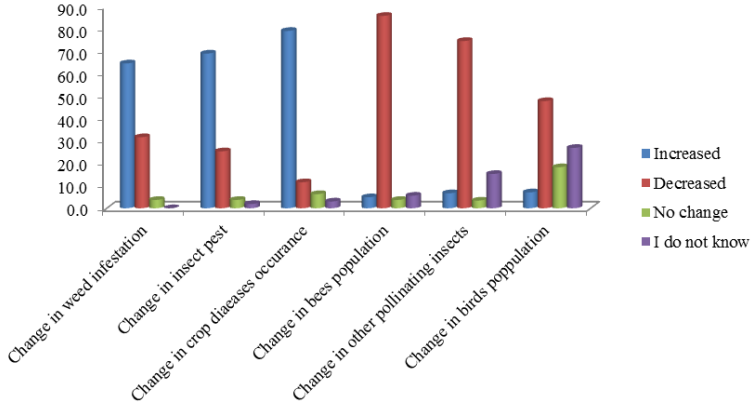

Figure 6. *Perceived health effect of pesticides on the environment.*

Farmers should refrain from applying insecticides during the flowering stage of crops and vegetables to maintain the pollinating insects' safety. Farmers should apply insecticides in the evening when pollinators halt to gather nectar and pollen [31]. According to Gadissa *et al*., about 31.70% of the Gudeya Bila district of East Wollega Zone farmers reported the bee's death after pesticide application, with 52.90% and 15.40% of the bees showing aggressive and anomalous behaviour, respectively [23].

Pesticides have the potential to harm non-target plants and animals and are likely to pose striking effects on birds that are in the higher trophic levels of the food chains. Pesticides also kill grain and plant-eating birds, and the extinction of many rare bird species has been reported. Populations of insectivorous birds have declined because insecticide use has caused them to lose their insect food in agricultural fields [32].

Unwise pesticide use destroys beneficial insects, microorganisms and predators that naturally limit the amount of crop damage caused by insect pests [33]. Spraying of pesticides has also been linked to declines in the population of rare species of animals and birds [2]. A study conducted in Ethiopia by Mergia *et al*. reported that farmers in the Lake Zeway area had noticed a decrease in the numbers of insects and birds in the area over the last two years, and their vegetable fields are rarely visited by honey bees [20].

3.10. Households` Knowledge on Exposure Routs and Pesticide Pictograms

The survey result showed that participant farmers had a better understanding of the exposure routs of pesticides. The majority of the farmers (72.8%, 97.8%, and 97.4%) claimed that they knew pesticides could enter the body through the skin, nose/mouth and eyes (Figure 7).

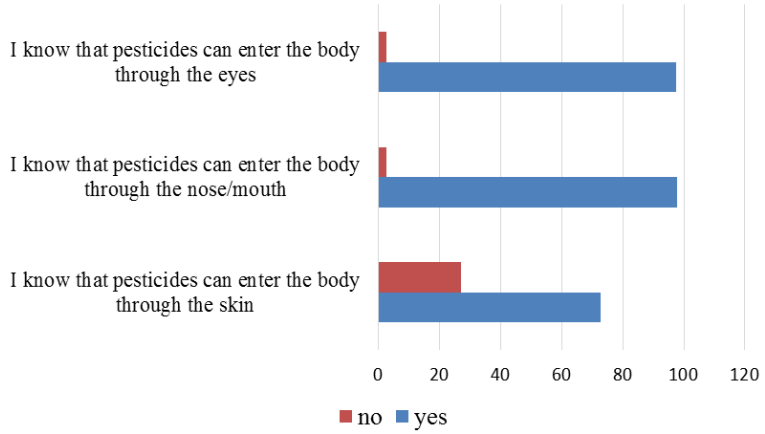

Figure 7. *Farmers knowledge on pesticide exposure routs.*

Depending on the type of pesticides, PPE use practice of the applicators, and the status of the spraying machine, a considerable volume of pesticides may enter the body via the skin, the eye, nose and mouth during weighing, mixing, application and disposal because of splashing, spillage and drift of pesticides. The toxicity level depends on the pesticide formulation, the area of the body exposed and the intensity of the exposure. The research finding is consistent with Endalew *et al*. study in Bahir Dar, Ethiopia reported that the floriculture workers understood the route of entry into the body parts were eyes, skin and ingestion [28]. Another study by Mergia *et al*. reported that vegetable farmers in the Lake Ziway area of Ethiopia understand how pesticides enter via eye, oral, inhalation and derma of the body. According to [12], Barbadian farmers understand that nasal, oral, and dermal are possible pesticide exposure routes. The majority of Ghanaian cocoa producer farmers know that the skin, eyes, nose and mouth are pesticide exposure routes [34]. Even though farmers in the study area are cognizant of pesticide exposure routes, they lack the use of PPE components that can protect their skin, eyes, nose and mouth.

Pesticide manufacturers provide safety precaution statements and pictograms to protect the farming community from the negative impacts of pesticides. Depending on the literacy level, farmers and pesticide applicators read and understand those precaution statements and pictograms from the pesticide containers, leaflets and labels. The majority of the respondents in the study area didn't understand the intended pictogram messages (Table 7). A slightly better understanding was observed from the message 'wear protection over nose and mouth; wear a mask (48.51%). The understanding is attributed to the COVID-19 pandemic awareness and familiarity during the time to use a mask.

Table 7. *Farmers knowledge on understanding pesticide pictograms.*

Type of pictograms	Pictogram message	Farmers understanding in percentage	
		understood	Not understood
Storage pictograms	Keep locked and reach out of children	18.66	81.34
Activity pictograms	Handle carefully – liquid product	35.82	64.18
	Handle carefully – dry product (powder or granular)	33.58	66.42
	Apply with a hydraulic backpack sprayer	41.42	58.58
Advice pictograms	Wear chemical-resistant gloves	42.91	57.09
	Wear eye protection	9.33	90.67
	Wear rubber boots	45.9	54.1
	Wear protection over nose and mouth (wear a mask)	48.51	51.49
	Wear overalls	18.66	81.34
	Wash after use	16.04	83.96
Warning pictograms	Dangerous/harmful to animals	27.99	72.01
	Dangerous/harmful to fish – do not contaminate lakes, rivers, ponds or streams	2.99	97.01

In our observation, pictograms on pesticide containers were too small in size to recognize and understand by farmers. Even some farmers are reported that they never saw the pictograms on pesticide containers. Almost all labelled pesticides in the study area had safety information in the local language. Even though written safety information is in place on pesticide containers, due to the prevalence of high illiteracy, farmers didn't understand the messages. Global evidences showed that high levels of illiteracy among individual farmers critical safety information is often not communicated [4]. Only 20% of farmers in Burundi and 17.3% in Rwanda read and understand the pesticide label. Few farmers (3.4% and 13.4% in Burundi and Rwanda, respectively understand the toxicity of pesticides from their labels [24].

4. Conclusion and Recommendations

Alike the practice in several other developing countries,

farmers in the study area mainly stored pesticides in home and kitchen that it can affect family members health. Farmers were using PPE components inadequately. The unavailability of complete PPE and essential PPE components in the study area is a critical problem. Farmers' good practices of calibrating and washing spraying machines before and after spraying should be promoted. Application of pesticides beyond the manufacturer's recommendation would increase pest resistance and damage non target organisms. Farmers adhere varying re-entry periods without PPE after they apply pesticides. Visiting freshly treated fields before the interval may affect the health of farmers and bystanders. After operation of pesticide spraying bathing and washing clothes were good hygienic practices frequently used by farmers. Acute health symptoms are indicative of mild and moderate level of poisoning due to poor pesticide handling practices. The decline in the population of bees, other beneficial insects and birds is alarming. Knowledge on pesticide exposure routs found to be good despite of improper PPE usage. Based on the results of this study, there is a need to improve the knowledge and skill of farmers to comply with pesticide safety measures and standards. Therefore, it is recommended that providing awareness creation training to the farmers will increase their perception and knowledge towards safe pesticide use and management.

Abbreviations

HHH	Head of the Household
Masl	Meter Above Sea Level
PPE	Personal Protective Equipment
REI	Restricted Entry Interval

Author Contributions

Abebaw Adamu: Conceptualization, Investigation, Project administration, Supervision, Writing – original draft

Anduamlak Assaye: Formal Analysis, Data curation, Methodology, Resources, Software, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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