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Review Article

The Significance and Implications of Pesticide Residue on Fruits and Vegetables in Ethiopia: An Overview

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Abstract: Crop protection is an essential component of fruit and vegetable production in Ethiopia. Farmers utilize various protection strategies and methods to minimize the level of damage by pests, but among protection strategies pesticide application is the predominant method. There is high dependency of farmers on pesticide control of pests in fruits and vegetable production. Pesticide application encourages farmers to rely more on pesticides than on other pest control methods because of quick results obtained. This will result in accumulation of pesticide residues on the crops. Pesticide residue refers to pesticides that may remain on or in food after they are applied to food crops. Hence pesticide residue includes the pesticide that is remained in the sprayed produce such as fruits and vegetables and bioaccumulation in animals and products such as fish, meat, eggs and dairy. Pesticides used on fruits and vegetables leave residues on the exposed crops which expose human beings to adverse health effects. The continuous use of pesticides in fruits and vegetables as practiced by farmer's poses a health risk to consumers and may lead to higher pesticide residues. Organochlorine and organophosphate pesticides which are the most hazardous and banned chemical groups are still in use in Ethiopia. Good pesticide monitoring and program to evaluate consumer risk for the Ethiopian people is mandatory.

Keywords: Pesticide Residue, Health Risk, Fruits and Vegetables, Pesticide Persistence

1. Introduction

Agriculture plays a significant role in Ethiopia's economy and provides livelihood for a growing population. However, Biotic and abiotic factors are among the major constraints of vegetable and fruit production. Pests are causing an enormous loss for productivity and production of crop. Pests can be generally defined as the plants or animals that jeopardize our food, health and/or comfort. There is a big damage due the pre-harvest and post-harvest of crops.

Vegetables and fruits are the main source of healthy human diet. Myriad of elements are present in fruits and vegetables that are healthful for human being. There is a tremendous effort to promote the production and productivity of fruits and vegetables in Ethiopia and the sector is given high emphasis. They are also attacked by different destructive pests. To prevent their damage and to preserve their quality, pesticides are used to destroy pests. The use of pesticides however, often leads to the presence of residues in the fruits and vegetables after harvest to the consumers.

Pesticides are defined by the U.S. Environmental Protection Agency (EPA) as any substance or mixtures of substances intended for preventing, destroying, repelling, or mitigating any pest. Pesticides are widely used in agriculture to increase the yield, improve the quality, and extend the storage life of food crops [1]. Pesticides are considered a vital component of modern farming, playing a major role in maintaining high agricultural productivity. Pesticides work by attracting, seducing and then destroying or mitigating the pests. When carefully applied only when needed, pesticides can contribute to increased productivity and allow us to feed and protect the growing human population [2].

Pesticide application is still the most effective and accepted means for the protection of plants from pests, and has contributed significantly to enhance agricultural productivity and crop yield [3]. Farmers rely heavily on the use of pesticides. A large number of pesticides have been applied in agricultural areas all over the world. There are more than 1000 pesticides used around the world to protect food from pests [4]. About 5.2 billion pounds of pesticides are used worldwide per year [5].

Hence fruits and vegetables are subjected to many applications of pesticides for protection from pests. They are often eaten fresh and unprocessed, which cause the main source of pesticide residues intake for human. Consumption of conventionally grown fruits and vegetables is a major source of pesticide exposure. Inappropriate use of pesticides in agricultural production pollutes the environment, threatens ecosystems, risk for food safety, and affects human health. The presence of pesticide residue in food is of great concern for consumers because it is known to have potential harmful effects.

Government extension programs in Ethiopia also encourage the use of pesticides arguing that farmers have no alternative [6-8]. The recent agriculture improvement in the country demands high pesticide usage. Many reports revealed that the pesticide use trend in Ethiopia is increasing [9].

Now a day food safety has become an important issue of concern for everyone and pesticides are one of the risks of food safety. Application of pesticides could result in leftover of residues on the fruits and vegetables. Fruits and vegetables had higher frequencies of residues than the other groups of commodities examined [10]. Most of the pesticides are persistent for degradation and remain in the produce and cause hazard for the consumers. This can be a potential threat to the local community and ecosystems. Residues of pesticide contaminants pose a significant threat to human as well as agricultural landscapes and surrounding environments.

Although pesticide residues often exceed the maximum residue limits in Ethiopia, consumer awareness on health issues, due to food contaminants, is low. The pesticide consumptions are increasing in type and quantity from period to period in Ethiopia. However, the application technique and awareness by farmers on pesticide residue is poor. Despite widespread use of pesticide in the country, monitoring of pesticide residues on fruits and vegetables is almost absent. Also little attention has been paid to pesticide residues in fruits and vegetables. Consequently, pesticide residue is threatening the export of fruits and vegetables from Ethiopia. Therefore, the objective of this review paper is to address the prominence of pesticide residue in Ethiopia and its implication.

2. Pesticide Use in Ethiopia

Several reports indicate that pesticide use in Ethiopia is at a tremendous increase. At present, almost all agricultural pesticides used in Ethiopia are imported, even if Adami Tulu Pesticide Plc. is formulating some pesticides. About 2,245 metric tons of pesticides were formulated at the company in 2012 [11]. For instance there are more than 300 chemicals as pesticides and growth regulators are used in flower industries [12]. Ethiopia has imported 3,611 metric tons of pesticides in 2012 [8]. According to Mahmood et al. [5] major classes of the current and widely used pesticides include organochlorines, carbamates, organophosphates, pyrethroids and neonicitinoids (Table 2). Some farmers use pesticides as a protective measure, meaning they spray even when no signs of pests. Farmers use more than four types of pesticides during one cropping season in the country [9]. The same pesticides may be applied for a wide range of crops.

The worldwide pesticide consumption reported by FAOSTAT is 4,116,832 tons of active ingredients in 2016, but less than 1% of the total applied pesticides gets to the target pests [13]. Concerning the type of pesticide used in Ethiopia, there are several disputing reports. Of the total of 4,128.1 metric tons of active ingredients that were used in Ethiopia at 2016, the largest proportions (75%) were herbicides, followed by insecticides (15%) and fungicides (9%) [14]. Insecticides are used by majority of the farmers in Ethiopia followed by fungicides and herbicides [6]. Conversely Kalayou and Amare [15] reported that herbicides are more frequently used by farmers followed by insecticides. However, larger proportion of insecticides and fungicides are applied on vegetables and fruits than other crops, this is because these pests are more prevalent on the crops [16]. Consequently various classes of pesticides including insecticides, fungicides and herbicides, are regularly applied to fruits and vegetables in Ethiopia (Table 1).

Improper management of pesticides in in Ethiopia is the major challenge, including inappropriate selection, over application, fallacy at the time of application, non-targeted application, lack of monitoring of pesticide use and efficacy, poor storage practices and improper disposal of the obsolete remains [11]. This has resulted in high risks to human health, environment and biodiversity. There are more than 400 severely contaminated sites in Ethiopia [17].

Table 1. *Commonly used pesticides in Ethiopia by vegetable and fruit farmers.*

Trade name	Active ingredients (AI)	Chemical group	Target pest	WHO Class*
Insecticide				
Malathion/ Ethiolathion	Diethyl (dimethoxy thiophosphorylthio)	Organophosphate	Any worms, Maize weevil	III
Helarat	Lambda-cyhalothrin	Pyrethroids	Thrips, bollworm	II
Selecron	Profenofos “Q” 720 g/l	Thiophosphate	Thrips, aphids, Maize stalk borer	II
Profit	Lambda-cyhalothrin	Pyrethroids	Onion thrips, leaf hoppers, pea aphids	II

Trade name	Active ingredients (AI)	Chemical group	Target pest	WHO Class*
Dimethoate/ Ethiothoate/ Agro-Thoate/ Dimeto	Dimethoate	Organophosphates	Aphids on field pea, Russian Wheat Aphid	II
Karate	Lamda-cyhalortin	Pyrethroids	Thrips, Armyworm, Aphids	II
Endosulfan/ Ethiosulfan	Endosulfan	Organochlorine	Bollworm	Ib
Decis	Deltamethrin	Pyrethroids	Ballworm, aphid, fruit-borer	II
Diazinon/ Ethiozinon	Diazinon	Organophosphates	Boll worm, termite, stalk borers, armyworm, sweet potato butterfly	II
Fungicides				
Bayleton	Triadimefon	Triazoles	Powdery mildew, late blight, rust	III
Mancozeb, Indom, Unizeb, Fungozeb, Ethiozeb, Mancolaxyl	Mancozeb	Dithiocarbamates	Late blight, leaf spot, rust on tomato, potato, onion	II
Acrobat WG	Dimethomorph +Mancozeb	Dithiocarbamates	Downy mildew on flowers	U
Kocide	Copper hydroxide	Inorganic compounds	Early and late blight	III
Ridomil Gold	Metalaxyl-M	Acylalanine	Purple blotch, Late blight and downy mildew on tomato and onion	III
Tilt/Bumper	Propiconazole	Triazoles	Rusts, late blight, cercospora leaf spot	II
Victory	Metalaxyl + Mancozeb	Dithiocarbamates	Late blight	II
Natura	Tebuconazole	Triazoles	Early blight, purple blotch, late blight on tomato, potato & onion	III
Thiram Granuflo 80 WP	Thiram 80% WP	Dithiocarbamates	Seed decay and damping off disease	III
Herbicides				
Roundup/Glyphosate	N-(phosphonomethyl) glycine	Organophosphate	Annual & perennial weeds in coffee	II
2,4 D/Dacamine	2,4-Dichlorophenoxyacetic acid	Organochlorine	Broadleaf weeds in wheat, barley, teff, maize and sorghum	II
Pallas 45 OD	Pyroxsulam	Triazolopyrimidine	Wide range of weeds on wheat	III
Topic	Clodinafop-propargyl	Aryloxyphenoxy-propionate ‘FOPs’	Grass weeds	III

*- Ia: extremely hazardous; Ib: highly hazardous; II: moderately hazardous; III: slightly hazardous; U: Unlikely to be Hazardous.
Source: Mengistie et al. [9]; Gesesew et al. [18]; Sahilu [11].

3. Pesticide Residues in Food

Pesticides contain different kinds of active reagents, on which basis the pesticides are classified. These active reagents possess different types of action on pests that their action feat. Pesticide residues are the deposits of pesticide active ingredient, its metabolites or breakdown products present in some component of the environment after its application, spillage or dumping [19]. If the pesticides contaminated food is consumed by human being, then these pesticides can also harm human being. There is no differentiating characteristic of pesticides, to differentiate between pests and human beings [20].

Exposure of the general population to these pesticide residues most commonly occurs through consumption of treated food sources or being in close contact to areas treated with pesticides. Pesticides residues contaminate soil and water, persist in crops, enter the food chain, and finally are ingested by humans through food and water [21-22]. Pesticide residues in food and crops are a result of direct application of pesticides to crops growing in the field, and to a lesser extent from pesticide residues remaining in the soil [23]. The applied pesticides and/or their degradation products may remain as residues in the agricultural products, which becomes a concern for human exposure.

The awareness and deeds of farmers in the use of pesticides have become crucial factors in determining the safety of food. The occurrence of pesticide residue complex (more than one residue) is not uncommon in fruits and vegetables, because they are prone to be treated with several insecticides, fungicides and herbicides. The effect of an individual chemical could be enhanced or changed if it is combined with another substance.

Pesticide residues in fruits and vegetables can be caused by a number of factors including, high dosage and frequency, wrong pesticide, label not followed, lack of awareness, short withholding period, poor pesticide regulation and monitoring and mismanagement [24]. Some peoples/costumers in Ethiopia complained that the vegetables sold in the market sometimes have the smell of the pesticide. This indicates that the commodities are available to the market within a short period of time after pesticide applications. However, harvest interval can sometimes lead to problems with crops that are continuously harvested. In such case it is better to use pesticides which have the shortest persistence.

Researches from different country indicate that fungicides as the most dominant detected residue followed by insecticides and herbicides residues in fruits and vegetables [25]. Even if pesticide residue status in Ethiopian crops are not well monitored, high level of residue is expected. Mekonen et al. [26] has detected unacceptable level of hazardous pesticide residues like Dichloro-Diphenyl-Trichloroethane (DDT), endosulfan, cypermethrin, and permethrin from coffee and pepper in Ethiopia.

Exportable agricultural products must fulfill the required criteria of pesticide residue to the importing countries. Due to lack of resource management and oversight, Ethiopian agricultural products are at risk of containing high levels of pesticide residue. For instance, Japan banned Ethiopian imported coffee from entering the Japanese market due to high levels of pesticide residue that were detected [27]. Another report revealed that all the food items examined for residue contained 1 or more pesticides and more than 33% of the samples were above the maximum residue limits [26]. In a similar study of pesticide residues has detected Diazinon residue in wheat at a level of 125µg/Kg [28]. Several OCPs such as DDT and Endosulfan have been detected above the detection limits in honey [29], while 2,4-D, aldrin, Endosulfan and p, p-DDT in wheat at the farm and market level has detected detected [30]. A similar study by Deti et al. [31] detected varying levels of six OCPs from cow and goat milks in Ethiopia, which indicates there is high bioaccumulation of pesticide residue in the country.

4. Fate of Pesticides in the Environment

Pesticides may be of any kind, synthetic or natural chemicals. Environmental fate of pesticide residues is an issue which receives considerably more attention due to pesticide residue limit requirements in food, drinking water supplies and fruits and vegetables. The fate of pesticides (transport, persistence and degradation) in the environment is influenced by many processes like biological, physical, and chemical reactions that determine their persistence and mobility and the nature of the pesticide. All the applied pesticide does not reach the target pest. Pesticides that miss their target pest end up in air, surface and ground water, bottom sediment, food and non-target organisms, including human and wildlife.

Many pesticides are not easily degradable, they persist in soil, leach to ground and surface water and contaminate environment. Depending on their chemical properties they can enter the organism resulting in bioaccumulation. Most of the potential toxic pesticides have bioaccumulation in food chains and biomagnification potential and consequently influence also human health. In addition to the chemical type, the rate of pesticide degradation can be affected by soil type, type of microbe involved, and climatic conditions [32]. Microbial population is abundant in the top soil owing the utmost decomposition; if the pesticide leached deeper few microbes will encounter it.

A pesticide is persistent if the active ingredient only disappears from the environment at a very slow rate [33]. The persistence of different pesticides varies considerably by their chemical class (Table 2). Some pesticides are more persistent and reside in our environment for a long duration. The longer the compound persists before its degradation, the longer it is subject to the forces of leaching. Persistence of pesticides in soil can vary from few hours to many years in case of organochlorine pesticides (OCP) [34].

Table 2. *Major Classes of Pesticides.*

Class	Group	Examples
	Organophosphates	Chlorpyrifos, Diazinon, Malathion, Dimethoate, Dimefox, Abate
	Carbamate	Aldicarb, Bendiocarb, Carbaryl, Fenoxycarb, Thiram, Ferban Methomyl
Insecticides	Pyrethroids	Allethrin, Permethrin, Tetramethrin, Cypermethrin, Deltamethrin Dimethrin, Tetramethrin
	Organonitrogen	Chlorprophan, Aldicarb, Carbendazim, Carbofuran
	Organochlorine	Lindane, Endosulfan, DDT, Chlorothalonil, Tetradiphon, Dicofol, Eldrin, Dieldrin
	Thiocarbamates	Triallate, EPTAC, Butylate
	Dithiocarbamates	Mancozeb, Manganese + zinc, Maneb, Metiram, Thiram
Fungicides	Phthalimide	Captan, Diflotan, Folpet
	Triazoles	Fenarimol, Myclobutanil, Triflumizole
	Dicarboximides	Iprodione
	Bipyridyls	Paraquat, diquat
	Acetanilides	alachlor, acetochlor, metolachlor, propachlor, flufenacet, dimethenamid
Herbicides	Glyphosate	Coneo, Cropphosate, Roundup, Weedall
	Chlorophenoxy	2,4-D, Dichloroprop, Mecoprop, Erbin, Sesone, MCPA
	Triazines	Atrazine, Atratone, Chlorazine, Cyprazine, Propazine, Turbutryn, Simetryn

Pesticide persistence is measured in terms of the half-life, or the time in days required for a pesticide to degrade in soil to one-half its original amount. The longer the half-life, the more persistent the pesticide is. Pesticides which have less than 30 days half-life are considered as non-persistent, while pesticide with 30 to 100 days are moderately persistent and with greater than 100 days half-life are persistent pesticides [32].

Persistent pesticides are characterized by low water solubility, persist in the environment, accumulate in the food-chain, lypophilic, travel long distances, concentrate in marine animals and may produce toxic effects [35]. Organochlorine pesticides, polychlorinated biphenyls, dibenzop-dioxins and dibenzofurans are widely distributed halogenated aromatic compounds which persistently contaminate the environment [36]. These compounds are chemically stable with long biological half-life which leads to high biomagnification in the food chain across a wide range of trophic levels [37].

Pesticides bound to soil organic matter or clay particles are less mobile, bio available but also less accessible to microbial degradation and thus more persistent. Addition of organic matter to soil can enhance sorption and reduce risk to water pollution. These chemicals are also subjected to long term atmospheric transport (Figure 1). Primarily they will deposit on animal and plant tissues for long period and become part of food chain.

According to Gavrilescu [32] there are two main reasons that persistent pesticides persist in nature. First, the conditions necessary for their biodegradation are not ever present. The microorganisms that are capable of biodegrading these toxic compounds may be absent at the contaminated places. The second possibility is that the compound could be resistant to biodegradation and also it could be unable to cross the cell membrane for breakdown by intracellular microbial enzymes. Ethiopia still relies largely on less expensive, older (established), non-patented (generic), and more acutely toxic and environmentally persistent pesticides.

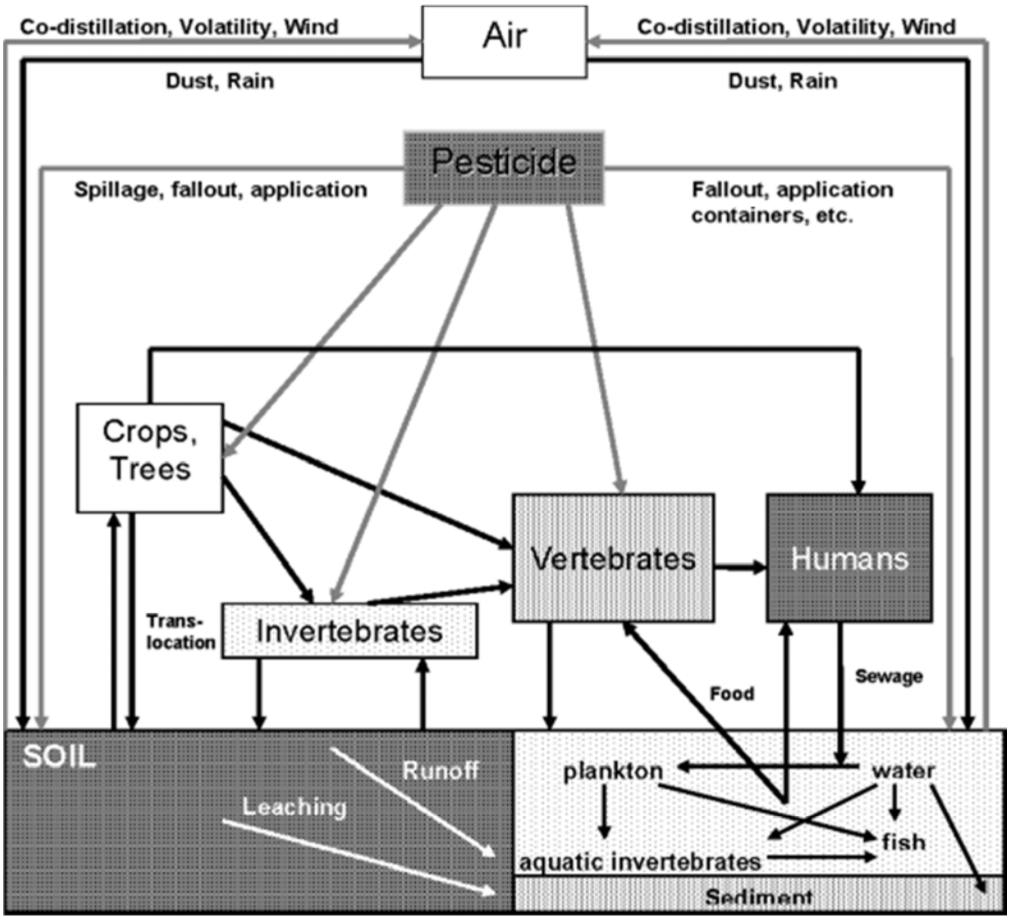

Figure 1. Fate of pesticides in the environment.

5. Health Risks of Pesticide Residue

The presence of pesticide residue in food is currently a great concern among consumers. Pesticides cause potential toxicity to human beings and animals. The presence of pesticide residues in primary and derived agricultural products result in serious health concerns for consumers. They are toxin human at any stage including care at storage, preparation, application, post-application and their residue in food. Pesticides are potentially toxic to humans and can have both acute and chronic health effects. Human health hazards vary with the extent of exposure. Moderate health hazards include flu, skin diseases blurred vision and headache, while severe health hazards include paralysis, blindness and even death [38-39]. The acute toxicity of pesticide includes irritation, allergic sensitization, enzyme inhibition, oxidative damage, inhibition of neurotransmission uncoupling of oxidative phosphorylation [35].

Some pesticides are related to carcinogenesis, endocrine disruptions, birth defects, reproductive disorders and cardiovascular diseases [40]. The effect of pesticide on human health depends on type of pesticide, quantity, mode of exposure, duration of exposure, age, sex, health condition etc. The toxicity of a pesticide depends on its function and other factors. For example, insecticides tend to be more toxic to humans than herbicides. Potential health effects and primary exposure routes vary by chemical. Human being can be exposed to pesticides through oral, dermal and inhalation routes. The most common routes of exposure for the general population are ingestion of a treated food source and contact with applications in or near residential sites. A study by Juraske et al. [41] revealed that exposure to pesticide residue through diet is assumed to be five orders of magnitude than other exposure routes such as air or drinking water. Food exposure to pesticides accounts for more than 90% of total exposure [42].

Nearly 1,000 people die every day from acute pesticide poisoning and many more suffer from chronic ill health [43]. WHO estimated at least 735,000 people annually suffer specific chronic defects and a possible 37,000 cases of cancer in developing countries [44]. Long term/chronic pesticide exposure has been linked to the development of Parkinson’s disease; asthma; depression and anxiety; cancer, including leukaemia and non-Hodgkin lymphoma; and attention deficit and hyperactivity disorder (ADHD) [43]. The applied pesticide and/or their degradation products may remain as residues in the agricultural products, which becomes a concern for human exposure.

People who face the greatest health risks from exposure to pesticides are those who come into contact with them at work, in their home or garden. Pesticides have become serious food contaminants, posing a threat to human health. All consumers in Ethiopia are at chronic risk of hazardous pesticides [45]. High poisoning rates among women and children (more than 71% cases) were also documented in Ethiopia [46]. Similar experiment identified detectable quantities of OCPs in human and cow milk [47]. All these indicate that Ethiopia is at high risk of pesticide residue, off them most are persistent pesticides. The hazard to the environment and the risks to human health are well above the minimum threshold of safety in Ethiopia [19]. Westbom et al. has detected a significant concentrations of pesticide residue level at Upper Awash Agro Industry of Ethiopia most of which were at high concentrations and of hazardous pesticides [48]. The maximum residue levels (MRLs) limit the types and amounts of residues that can be legally present on foods are set by regulatory bodies worldwide. MRL represent the maximum concentrations of pesticide residues, which are legally permitted in food crop.

Neurodevelopment disorders due to exposure to various industrial chemicals such as pesticides during early fetal development can cause permanent brain injury [49]. Pesticide residue has also related to infertility. Chiu et al. [50] has revealed that consumption of high pesticide residue in fruits and vegetables is associated with lower total sperm count, ejaculate volume and percentage of morphologically normal sperm among men. Pesticide use patterns of smallholder farmers are more complicated compared with large-scale farmers, as they are usually resource-poor as well as risk-averse. In addition, due to high exposure and unsafe application techniques, smallholders experience more pesticides health risks than larger-scale farmers [51-52]. Food directly brought from fields may have higher pesticide residue exposure [35].

6. Impacts of Pesticides on the Environment and Biodiversity

Pesticides may also be harmful in the environment when non-target organisms are exposed. Consequently, exposure to pesticide residue can damage not only the environment, but also have permanent adverse effects on entire populations. Ethiopia is one of the rich biodiversity country and diverse ecosystem. However, they are affected by pesticide contaminations. Pesticides are applied for protection from the pest, but the majority of pesticides are broad spectrum and do not only affect targeted pest populations but also affect non-target plants and animals too [34]. Pesticides can get into soil and water via drift during pesticide spraying, wash-off from treated foliage, runoff from treated area, leaching or direct application onto soil and water surface. Pesticides are a concern for sustainability of environment and global stability. It has been reported that about 10 million non-target organisms are poisoned by pesticides each year throughout the world [53]. This implies pesticide had paramount adverse effect on species diversity.

Water and soil contamination of pesticide depends mainly on nature of pesticides (water solubility, hydrophobicity), soil properties, weather conditions, landscape and biological activities. Streams and rivers were frequently more polluted that ground waters and more near the areas with substantial agricultural and/or urban land use. A research conducted in Ethiopia indicates that there is a considerable amount of pesticide residue in surface and drinking water [45, 54-55]. The contaminated water is also used as irrigation for vegetables and fruit production which pose another sources of pesticide residue to the consumer. The Environmental Working Group (EWG) [56] has released a list of the 12 most pesticide-contaminated vegetables and fruits (i.e., apples, strawberries, nectarines, peaches, celery, grapes, cherries, spinach, tomatoes, sweet bell peppers, cherry tomatoes, and cucumbers). However, in Ethiopian case vegetables are more contaminated and high residue than any other crops.

Although developing countries use only 25% (Africa accounts for less than 5%) of the pesticides produced worldwide, they experience 99% of the deaths. This is because the use of pesticides in these countries tends to be more intense and unsafe, while regulatory systems are generally weaker [35, 57-61]. Mengistie et al. [9] noted that some farmers in Ethiopia are using expired pesticides and pesticides without manufacturing and expiring date for vegetables and fruits. The majority of farmers do not follow appropriate safety precautions with regard to pesticide formulation and application. Lack of awareness of on the impact of pesticide on environment and biodiversity is also a challenge in Ethiopia. The environmental impacts of pesticides are not well understood by farmers in Ethiopia [9, 62].

Animals may be poisoned by pesticide residues that remain on food after spraying. Pesticides are also found to be toxic to beneficial soil microorganisms like fungi, actinomycetes, symbiotic nitrogen fixating bacteria and caused changes in microbial community structure [63-64]. Nematodes, springtails, mites, micro-arthropods, earthworms, spiders, insects and all other small organisms can also be affected by pesticides [43]. Misuses of pesticide increase environmental risks of pesticides. Many researches indicate that Ethiopian water bodies mainly lakes and biodiversity inside them are highly contaminated, especially at Rift valley of Ethiopia.

7. Pesticide Regulation

To ensure the safety of food for consumers, pesticide regulation is very important. The pesticides must undergo extensive efficacy, environmental, and toxicological testing to be registered by governments for legal use in specified applications. Pesticide registration is an important aspect of pesticide management that ensures that the pesticide product released in the market is authorized and is used only for the intended purpose. About 25% of developing countries lack any kind of legislation to govern the distribution and use of pesticides, and 80% lack the resources to implement and enforce the legislation [61, 65].

Registration of pesticides in Ethiopia involves simple efficacy trial and assessment of the pesticide's properties, like their basic physicochemical properties and their toxicity classification status and active ingredients. In Ethiopia continuous monitoring of pesticide residual status in fruits and vegetables is mandatory but not yet monitored. In some Africa countries including Ethiopia, OCPs which are highly toxic and persistent in the environment are still in use for agriculture and public health purposes [9, 55, 66]. A survey report revealed that 29% of vegetable producing farmers in the Ethiopian Rift Valley area were found to be using DDT for vegetable production, which is extremely persistent and toxic pesticide [11].

Banned, expired and persistent pesticides are still used by farmers in Ethiopia. More than 1,500 tons of obsolete, unwanted and banned pesticides dumped in the country and Ethiopia is the second most pesticide-contaminated country in Africa next to Morocco [17]. Banned and restricted pesticides remain easily accessible in informal markets. According to Assefa [67] 58% of pesticides used in Ethiopia are very hazardous according to WHO risk classification (class II) and about 7% are extremely hazardous (class Ia and Ib), the remaining 35% pesticides are moderately hazardous and low risk pesticides (class III and U).

In Ethiopia only the effectiveness of the pesticide for the control of pests is used for the criteria of pesticide evaluation by the farmers, hereafter their persistence and toxicity of pesticides should be assessed. While for farmers, pesticide performances are one of the most important criteria for choosing and using pesticides [9; 68-69]. Many countries have set maximum residue limits (MRLs) of pesticide residues in various raw and processed foods. But in Ethiopia there is no such control limits yet. Therefore, enforcing pesticide control policies are mandatory in Ethiopia to ban the import and use of highly toxic pesticides in agricultural production and to promote the use of new, low toxicity, low residual pesticides and promotes organic farming. Pesticide usage is not properly regulated and no comprehensive studies have been undertaken to determine the pesticide residues in fruits and vegetables in the country. Intensified monitoring program should be carried out. Laws and policies are needed to regulate the behaviors of stakeholders for ensuring food safety. Mengistie [16] has stated the major constraints that hinder the implementation of pesticide policy in Ethiopia including lack of appropriate pesticide registration, distribution and use system, inadequate monitoring of pesticides once registered, lack of regulations and directive to implement the policy, weak inspection to dealers and end users, lack of cooperation between stakeholders.

To promote pesticide governance that protects the environment and human health, Ethiopia has developed policy for pesticide registration and control. However, major gaps exist between pesticides policy on paper and its implementation in practice [7]. The risk assessment for a pesticide is performed by estimation of Hazard Quotient (HQ). The HQ is calculated by dividing the exposure with the Acceptable Daily Intake (ADI) for the individual pesticide [10].

8. Challenges of Pesticide Use in Ethiopia

Recent agricultural growth in Ethiopia resulted in higher demand for pesticides. Selection of the correct and less hazardous pesticide, precise rate, proper timing and techniques of pesticide application and after application cares in Ethiopia are lacking. Gesesew et al. [18] has reported that small scale farmers in Ethiopia has poor awareness of pesticide use, management and care. Despite the poor awareness of the farmers, pesticide traders has a decisive role on pesticide misusage, they are supplying unauthorized pesticides, cheap but persistent pesticides, expired pesticides and wrong instruction.

The need of pesticides in kind and quantity and the number of individuals involved in pesticide business is increasing from time to time. However, there is no proper record of the actual volume of pesticides used in vegetable production in Ethiopia [7]. Excessive and inappropriate use of pesticides in commercial and small-scale fruit and vegetable production is common practice in the country. Ethiopian farmers and also consumers has no awareness of pesticide residue on commodities [9], while 61% of farmers in China are aware that vegetables can contain pesticide residues and many farmers take measures to protect themselves [70]. Pesticide residue is also not given attention by the government. A study done in Ethiopia indicates that demonstrated lack of knowledge among small scale farmers as one of the contributing factors of pesticide residues [71]. Farmer's economic status is also one of the factors for misuse of pesticides and residue. Farmers with higher income are using more appropriate pesticides, while low income farmers use less expensive, broad-spectrum pesticides [9].

Application of pesticides in mixture is common practice among smallholder farmers, which may contain the same kind of pesticides (for instance mixture of two insecticides), fungicide and insecticides, fungicide and herbicides etc. They mix pesticides without any instruction which may be risky because the chemicals may be not compatible and reduced efficacy. It may also has significance on pesticide residue. The impact may be serious in high-risk groups exposed to pesticides, like production workers, formulators, sprayers, mixers, loaders and agricultural farm workers.

Farmers in Ethiopia apply pesticides incorrectly starting from the buying of the pesticide to the disposal. During buying the type and amount of pesticide is improper, use unsafe storage facilities, ignore risks and safety instructions, do not use protective clothes when applying and mixing pesticides, do not follow proper application methods (rate and uniformity) and dispose containers unsafely. Even some farmers use the container for storage of food items [18]. More than 71% of farmers in Ethiopia did not use personal protective equipment while spraying pesticides [6, 71]. Over 70% of the farmers never read pesticide labels [9, 71]. Some farmers even provide their produce to market within a short period of time after pesticide applications on fruits and vegetables (withholding period). More than 50% of the farmers spray pesticides on mature crops and sold the produce within three to five days [6]. Concerns about the toxicity, residue effects, environmental impacts or risk/benefits for themselves or consumers were not important considerations in pesticide selection by farmers [9]. Although most of these produces are consumed without processing and storage. Traditional processing of food significantly reduces pesticide reduce [72]. This increases the risks of contamination to the consumers.

Food crops are currently not tested for pesticide residue in Ethiopia, which is a concern for food safety. A considerable proportion of the pesticides applied in Ethiopia originate from unauthorized sources [9]. Laboratory facilities and other resources to monitor pesticide residue on commodities and environment are lacking in Ethiopia. Unauthorized pesticides are still brought in Ethiopia through illegal trading which may be recommended for specific crops are still in use in Ethiopia for fruits and vegetables, for instance Endosulfan products (proposed for cotton), Champion 50 % WP and Aldicarb (for flower) are frequently used [9].

Hence the best way is using integrated pest management (IPM) and other approaches for pest management, in which the approach is no use or little use of pesticides leading to organic farming and safer produce. There is also an effort to promote IPM in Ethiopia and which was effective and improves the productivity of the farmers [73]. Even though the farmers rely only on pesticide as a way of controlling pest, they are willing to adopt sustainable pest control strategies. Establishment of ‘pesticide-free zones’ is a good strategy for preventing pesticide exposure. Good agriculture practices (GAP) in pesticide application can also reduce the risk of pesticide residue and contamination [33]. However, farmers require knowledge on pesticide application techniques and the suitable interval between harvesting and pesticide treatment. Farmers in Ethiopia most of the time obtain assistance from pesticide traders; they may mislead them, because their aim is increasing their market. The sustainable pesticide usage and handling and reduction of pesticide residue in Ethiopia on fruits and vegetables requires a collaborative effort of the responsible stakeholders, including government, farmers, traders, NGO’s, agencies and researchers. It is essential to generate accurate and reliable efficacy, toxicity and residue data on candidate pesticides. If pesticides are mandatory, follow manufacturer’s instructions, use protective equipment, respect re-entry times, pregnant women should not apply pesticides, use least hazardous chemicals, least dangerous mode of application.

9. Conclusion and Future Recommendations

Pests are important constraints to vegetable and fruit production in the tropics. To reduce the damage by pests, pesticides are repeatedly applied on these crops which result in residue for the consumer. Pesticide residues may contaminate surface waters through runoff from treated plants and soil or through spray drift during application. Pesticide residues on vegetables and other food products due to indiscriminate spraying also pose serious health threat to consumers and the environment. The health hazards associated with pesticide handling are little understood by the sprayers. Pesticide exposure is associated with a wide range of human health hazards, ranging from short-term impacts like headaches and nausea to chronic impacts such as cancer, reproductive disorders, endocrine disruption, birth defects and immune system disorders.

Fruits and vegetables are highly exposed crops for pesticide applications, which is a clear indication that consumers could be at risk of consuming high levels of pesticide residues. Hazardous pesticides are has to be controlled effectively at regulatory level. Proper pesticide usage and management has a significant role in improving agricultural sustainability and environmental safety. Pesticide residues in may also have a detrimental effect on export of fruits and vegetables which may be rejected. Therefore, comprehensive monitoring of pesticide use practice and pesticide residue in Ethiopia is essential, and awareness creation strategies for all stakeholders are indispensible. Pesticide distribution and their use should be monitored efficiently. Chemical pesticides should only be used when they are really needed and suitable registered pesticide products are available.

Competing Interests

The authors declare that they have no competing interests.

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