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Economics of Pesticide Use and Future Prospects: The Opportunities and Constraints in Ethiopia

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Abstract: Pesticides are important agricultural inputs in crop production processes worldwide. Developing countries are often handicapped by the lack of trained personnel, facilities and funds to get rid of obsolete pesticides. Pesticidecontrolmethods regardless of their intrinsic hazard, are used in the agricultural sector of Ethiopia. Compared to developing countries, the use of pesticides in Ethiopian agriculture is low and most of the pesticides are used in large-scale farming, especially in cotton and sesame production and some in horticultural crops. The majority of small-scale farmers are not using pesticides. However, some farmers use herbicides like 2, 4- D for weed control in cereal crops and pesticides against migratory locusts, armyworms and birds are used during outbreaks. The major problem associated with pesticides is their disposal. Pesticide use is very limited in smallholder agriculture and therefore pest management and related research in food crops should rely on an integrated pest management (IPM) approach and Bio-pesticides. Hence, the knowledge of pesticide use's possible hazards to the ecosystem should be improved, pest management systems that integrate all possible control measures should be developed and the implementation of pesticide regulations be strengthened.

Key words: Crop Pests · Pesticide · Economics · Environment · Hazards

INTRODUCTION

Ethiopia's population is estimated at 115 million, over 85 percent (97.75 million)live in rural areas and depend on agriculture for food and other necessities and agriculture contributes 46% of the country's gross domestic product [1]. Promoting sustainable agricultural production requires critical consideration of agricultural technologies and the identification of best practices. Pesticides are agricultural technologies that enable farmers to control pests and weeds and constitute an important input when producing a crop [2-4]. Although chemical pesticide use in Ethiopia was historically low, recent developments in increased food production and expansion in the floriculture industry have resulted in higher consumption of chemical pesticides. The impacts of pesticides in Ethiopia are much more aggravated by the limited knowledge among users on safe practices and the toxicological and chemical properties of these substances. Even worse, less is known about the long-term and indirect effects of pesticides on rural and urban communities as well as on local and national food production systems [5].

Ethiopia has endorsed many proclamations to minimize and control occupational and environmental risks particularly caused by pesticides (Pesticide Registration and control proclamation number 674/2010, Labor proclamation number 277/2003 and Environmental pollution control proclamation number 300/2002), previous studies showed that farmworkers had limited knowledge on pesticide hazards, lack awareness about safe pesticide management,poor hygienic and sanitation practices [5, 6]. Recently, Ethiopia has been considered as having the largest accumulation of obsolete pesticides in the whole of Africa. It was estimated that there were 402 stores at 250 sites containing 1,500 tons of obsolete pesticides [7] and the obsolete stocks were dumped at more than 1000 sites in Ethiopia [8].

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This estimate does not include the massive but unquantifiable amounts of pesticides soaked in soils. Nor does it include contaminated building materials, pallets, shipping containers and other miscellaneous items. While pesticides have increased agricultural production and improved public health, pieces of evidence in the last few decades have shown that they could also be detrimental to human health and the ecosystem. The real impacts of pesticides are not easily mapped in most circumstances. Acute effects are easier to observe, but they could also be confused with common illnesses. Pesticides may also cause chronic diseases such as cancer, reproductive disorders, birth defects and immune system disorders. Therefore, the objective of this paperis to review the economics of pesticide use, opportunities and constraints in Ethiopia.

Pesticide Development in Ethiopia

The Opportunities of Pesticide Development

Challenges to Crop Production Caused by Pests: Crop losses due to the emergence of new and/or more resistant pests (insects, plant pathogenic fungi, bacteria), the spread of disease vectors and the emergence of a pesticide treadmill, whereby farmers are obliged to pay more and more for a control program that does less and less good.It is, essential to note that losses due to pests, diseases and weeds also play important roles in reducing crop yields and thereby contributing to food insecurity, though updated information on the extent of their damage is generally lacking.

Losses by Insects and Rodents: Crop yield loss by major insect pests is dependent on the type of crop pest and the crop variety. According to the estimate by [9], the average pre-harvest loss for field crops (Cereals, Pulses and Oil Seeds) ranged between 15 to 40% and for horticultural crops (Root and Tubers, Vegetables and Fruits) between 13-29%, for coffee between 9 to 48% and for cotton between 21-60%. The average pre-harvest crop losses due to insect pests ranged between 17 and 41%. Losses to migratory pests can be catastrophic. For example, in 1958 the desert locust (*Schistocerca gregaria*) caused an estimated loss of 267, 000 tons of grain in Ethiopia. Losses due to vertebrate pests such as rodents and birds are estimated to reach between 10 and 25%. According to EARO [10], during the period 1995 to 1999, an annual average of 74.5 million Quelea birds infested an average of 1, 500 ha of sorghum.

Losses by Diseases: Crop diseases caused by fungi, bacteria, viruses and plant-parasitic nematodes inflict a significant loss on crops. For instance, according to the field study [9], losses on field crops ranged between 32-52%. Similarly, the average loss on industrial crops ranged between 22 and 44% and on horticultural crops ranged between 35 and 62%.

Losses by Weeds: Losses caused by weeds in selected crops have been reported to be as high as 100%. According to the findings by HARC [9], the average loss for field crops ranged between 49 to 65% and for industrial crops, it ranges between 45 and 83%. The overall average loss in crop yield is estimated to reach between 52-76%.

Pesticide Demand by Crop Producers and Costs of Pesticides

Pesticide Demand: Recent developments in increased food production and expansion in the floriculture industry have resulted in higher consumption of chemical pesticides. At present, almost all agricultural pesticides used in Ethiopia are imported. Only, Adami Tulu a pesticide formulation plant is formulating a few pesticides. This company uses imported active ingredients and solvents to formulate a portion of the pesticides required in Ethiopia [11]. The increase in imports and use of agrochemical inputs has followed the expansion of the crop production area in Ethiopia and contributed to yield increases. The total agricultural area in which pesticides were applied during the 2020/2021 production season was more than 4.46 million hectares of total cropland area and 6.85 million holders of total holders using inputs [12].

Pests are the drivers that encourage the application of pesticides in agricultural production because, without the application of pesticides, the loss of fruits, vegetables and cereals from pest injury would reach 78%, 54% and 32%, respectively. Pesticides have been used in response to these losses and played major roles in increasing agricultural production. This has resulted in an increased demand for pesticides, which has also been strongly pushed by interest groups, such as pesticide importers, wholesalers and retailers.

Costs of Pesticides: The costs of pesticide use are a minor alternative to traditional control mechanisms and time effectiveness to cover a large volume of farming and the reduced workforce needed for weeding, which frees labor for other tasks [14].

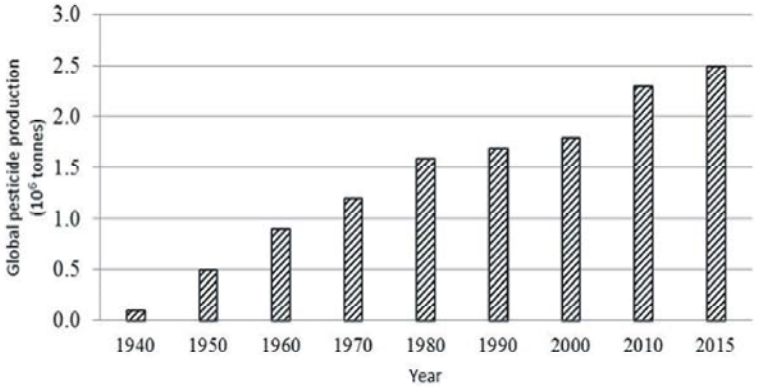

Fig. 1: Total global agro pesticide (active ingredients) production 1940-2015. Source: http:// faostat3.fao.org/ download/ R/RP/E [13].

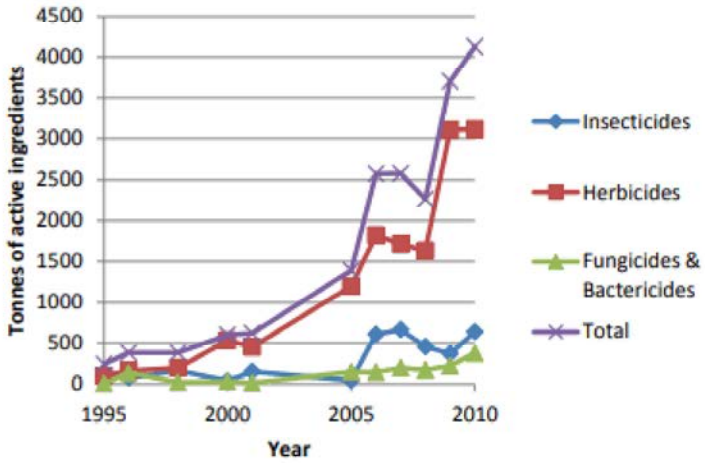

Fig. 2: Pesticide use in Ethiopia (1995-2010). Source http://faostat3. fao.org/browse/ R/RP/E. [13]

The Constraints of Pesticides Development

Environmental Hazards Associated with Pesticides Use:

Pesticide Poisoning: Population groups at risk are pesticide workers mixing or applying pesticides and children and others ingesting pesticides accidentally. The major problems in pesticide application to humansinclude at a time of contamination dealers, formulators, applicators and farmers. Pesticide contactwithhumans can occur through the skin (dermal uptake), through the respiratory system (inhalation), or by mouth (ingestion) and health effects include ocular, dermal, cardiovascular, gastrointestinal, carcinogenic, endocrine disruption, developmental, neurological and respiratory effects [15, 16]. The health risks and associated economic impacts from contamination of surface; and ground potable water supplies contaminated by pesticides containing wastes; Acute health effects resulting from contamination of food and water stored in pesticide containers, from the transportation of pesticide and foodstuffs in the same vehicle; Health risks from pesticide residues remaining on a crop after application [17].

Pesticide Residue in the Soil: Pesticides are introduced into the soil for destroying soil-dwelling pests, nematodes and the pathogens of bacterial and fungal diseases. Herbicides are widely introduced into the soil. Pesticides also get into the soil after treatment of the green organs of plants. They are washed off by atmospheric precipitation and carried off by the wind. Pesticides may get into soil in the form of their residues contained in leaves, roots, etc. Depending on the conditions poisonous chemicals may remain in the soil unchanged and retain their toxicity for a more or less prolonged time. Persistent use of DDT and its related chemicals can thoroughly undermine the productivity of the soil over time by destroying the

microorganisms and nutrients that nourish crops. This decreases the agricultural productivity of land and makes it vulnerable to desertification [8, 17].

Water Contamination: Pesticide residue in water can cause serious pollution; both groundwater, as well as surface water, may result in the death of fish and also have other ecological impacts; change in the organoleptic properties of water (its odor, taste, Negative effect on the process of oxygen formation by phytoplankton, on the vital activities of the inhabitants of the water ecosystems; impacts that transmitted along the food chains and accumulate in food products; Direct toxic action (acute or chronic toxicity) and indirectly (dimensioning of thecontent of oxygen dissolved in the water, a change in the chemical composition of water, extermination of water insects, etc.); Disturbing aquatic ecology; and adverse effects on wetlands aquatic flora, etc. Pesticides reach water either by direct application for controlling water-inhabiting pests or through surface run-off, industrial waste discharges, sewage effluents, accidental spillage, etc. Pesticide contamination of water can be hazardous both directly and indirectly to human beings and animals that live in water. The greatest damage owns to bioconcentration or biomagnification of persistent pesticides such as organochlorine insecticides. In addition, waste water from floriculture industries discharged into nearby rivers has enormous effects on the degradation of ecosystems [18].

Pesticide Contamination of Air: Takes place by drift and volatilization from soil or water. Contamination of the air may prove hazardous to persons engaged in pesticide application [15, 17].

Residue in Food: The residues, which build up in food owing to the application of pesticides to crops and the feeding of animals in contaminated food are a great concern to the public.Pesticide residues in agricultural products may also have a detrimental effect on export crops. If pesticide residue is above the maximum acceptable level set by the codex committee, the product is rejected. Moreover, [8] demonstrated that intensive and improper pesticide use in the field results in pesticide residues (MRLs) that are too high according to the Codex Alimentarius on marketed maize, teff, red pepper and coffee. Some banned pesticides and those not authorized for use in cereals, vegetables and coffee, such as organochlorines (e.g., DDT and endosulfan), were also detected [11].

Effects on Human Health: The use of pesticides creates substantial health impacts in all parts of the world. Pesticide effects can be decided broadly into two categories:Acute effects, which appear immediately or very soon after exposure andchronic effects, which may manifest themselves many years later and whose origins are often difficult to trace. Each year in the world, an estimated 1 to 5 million humans are poisoned by pesticides with 20,000 fatal [19]. Pesticide health-related impacts may include Headache, irritability, dizziness, loss of appetite, nausea, muscle twitching, convulsion, loss of consciousness and possible death, carcinogenic effects, neurobehavioral effect, reproductive deficits, diabetes and others.

Effects on Wildlife and Livestock (Non-targetspecies): Pesticides are designed to kill pest organisms and may also harm non-target species and resulted inpopulation decline through the use of pesticides over large areas, reproductive effects such as eggshell thinning, deformity and birth defects. Metabolic changes, tumors and cancer;behavioral changes;abnormally functioning thyroid glands;Sub-lethal or lethal poisoning of mammals and other vertebrates; through the extinction of the pest population losses of food sources for many birds; particularly migratory species;toxicity to bees which are pollinators, with adverse effects on the production of certain crops;long-term negative effects on the reproductive processes of birds of prey and aquatic species of certain insecticides (e.g. DDT). High mobility and biological amplification of persistent pesticides [6].

Damage to Apiculture: Farmers who produce primarily cereals, pulses and horticultural crops use various types of herbicides, insecticides and fungicides without due consideration of the damage to honeybee colonies. Several bee colonies either die or abscond from their hives due to the extensive use of agrochemicals [20]. Today the unwise application of herbicides and various pesticides is killing several honeybee colonies annually and thus has become critical in the development of the Apiculture sub-sector.

While working on flowers, bees are exposed to direct and indirect contact with pesticides which, depending on the mode of action and the concentration of an active substance, can lead to the sudden death of pollinating insects or cause death within a couple of hours following exposure [21]. It becomes dangerous when the level of pesticides or their residues in a beehive becomes high enough to adversely affect the functioning and

development of larvae [22]. Bees are highly susceptible to environmental changes and pollution, which is strongly reflected in the significant decrease in their survival rate [23].

The Major Causes of Pesticides' Effects on the Environment: Ethiopian farmers found pesticides to be supportive input for their agricultural production; however, their improper use in the past has shown that small-scale peasant farming and some large-scale mechanized agricultures have caused an impact on air, water, soil and human beings. Some of the underlining causes are outlined hereunder:

Lack of Awareness: Inadequate training, lack of appropriate and timely information about the proper use and management of pesticides, Inappropriate use of personal protective equipment (PPE), Wrong notion that pesticides are the best solution to pest problems, Poor guidance about the safe use and handling, Lack of standard safety practice, etc.

Improper Use of Pesticides: Wrong mix of different types of pesticides, Use of pesticides for unintended purposes, Use of pesticide containers for domestic uses, Wrong trade and Sectorial motives, etc.

Weak Enforcement: Absence or late issuance of regulations and guidelines, inadequate implementation of the issued regulations, weak monitoring or a follow-up activity and lack of well-defined incentive or punitive structure, etc.

Lack of Integration: Weak institutional setup and poor networking and exchange of information among key stakeholders.

Obsolete Pesticide Accumulation: Large quantities of obsolete pesticides can be accumulated due to inaccurate predictions of the occurrence of pests and poor pesticide management.

Economics of Pesticide Use and Risk Reduction

Major Economic Contributions of Pesticide Use: The occurrence of pests and diseases are the drivers that encourage the application of pesticides in agricultural production because, without the application of pesticides, the loss of fruits, vegetables and cereals from pest injury would reach 78%, 54% and 32%, respectively. Pesticides have been used in response to these losses and played major roles in increasing agricultural production.

Individual Farm: Vegetables and cut flowers are important sectors of Ethiopian horticulture in which pesticides are used intensively. In Ethiopia, some 6 million smallholders provide 95% of all vegetables and fruits supplied to domestic and regional export markets, such as neighboring African countries and the Middle East. The export of vegetables increased from 25,300 tons in 2002/03 to 137,000 tons in 2012/13 [24]. Some of the biggest problems confronting vegetable growers in Ethiopia are diseases and pests, which ravage their crops.Pesticides have been used in response to these problems and played major roles in increasing production. This has resulted in an increased demand for pesticides, which has also been strongly pushed by interest groups, such as pesticide importers, wholesalers and retailers.

Crop Yield Enhancement: The recent introduction of several different chemical groupsto pesticides has enhanced agricultural production by providing crop producers with a variety of options for better control of pests on the one hand while minimizing their side effects on the other [25].

Farmer's Livelihoods Improvement: When carefully applied only when needed, pesticides can contribute to increased productivity and allow us to feed and protect the growing human population [26].

Agricultural Sector: Pesticides are important agricultural inputs in crop production processes worldwide. In many countries, the pesticide sector is an important contributor to national income, employment and international trade. In many countries, the pesticide sector is an important contributor to national income, employment and international trade [2].

Mechanism to Reduce Risks Associated with Pesticide Use: Pesticides have played a major role in ensuring food security by helping to increase agricultural production and control vectors of disease [26]. Pesticides are most commonly used as plant protection products. Their main benefits are increasing crop yields or productivity by protecting crops from diseases, pests and weeds, preventing the deterioration of crop products in storage and extending the shelf-life of fruits and vegetables to maintain marketability [27]. When carefully applied only when needed, pesticides can contribute to increased productivity and allow us to feed and protect the growing human population [26]. The recent introduction of several different chemical groups to pesticides has enhanced agricultural production by

providing crop producers with a variety of options for better control of pests on the one hand while minimizing their side effects on the other [25].

To Humans: Although it is known that pesticides enhance crop production through improved control of pests, herewith contribute to the overall regional and global economy.When carefully applied only when needed, pesticides can contribute to increased productivity and allow us to feed and protect the growing human population [26].

To the Environment: In Ethiopia, the responsibility for registration, control of import and distribution of pesticides is given to the federal Ministry of Agriculture (MOA) by pesticide registration and Control Proclamation No.674 / 2010. The proclamation also underlines: that no person shall dispose of any pesticide in a manner that can harm human health and the environment; any employer shall provide facilities and protective clothing for the safe handling of pesticides to his employee; any employer shall give proper instructions and periodic medical check-ups for his employees while he permits or requests them to work with pesticides; an inspector assigned by the ministry can carry out surveillance to ensure conditions of registration complain. Environmental pollution control proclamation No 300/2002, aims at eliminating or when not possible, mitigating pollution including that from pesticides as an undesirable consequence of social and economic development activities [5, 6]. Integrated pest management andBio-pesticides are typically microbial biological pest control agents that are applied like chemical pesticides. The most beneficial advantages of bio-pesticides are that they have harmful residues that are not detected.

CONCLUSIONS

In general, the use of pesticides in Ethiopian agriculture is low. Most of the pesticides are used in large-scale farming, especially in cotton and sesame production and some in horticultural crops. The majority of small-scale farmers are not using pesticides. However, some farmers use herbicides like 2, 4- D for weed control in cereal crops and pesticides against migratory locusts, armyworms and birds are used during outbreaks. One of the major problems associated with pesticides is their disposal. Developing countries are often handicapped by the lack of trained personnel, facilities and funds to get rid of obsolete pesticides 1,500 tons of banned, decomposed or unwanted pesticides have been dumped across the country. For the cleanup of these pesticides, the FAO Collaborative Program on the Disposal of Obsolete Pesticides of the Plant Protection Service coordinates the project. Pesticides make pesticide use very limited in smallholder agriculture and therefore pest management and related research in food cops should rely on an Integrated Pest Management (IPM) approach.

Therefore, in the future improvement inthe knowledge ofdifferent types of pesticide use and possible hazards to the ecosystem, develop pest management systems that integrate all possible control measures and improve the level of integration of pest management practices in the animal and crop production systems and strengthen the implementation of pesticide regulations.

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