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Full Length Research Paper

Health risks of pesticides to non target species and ecosystem due to control of migrant pests in Tanzania

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Abstract

This report is a review of impacts of pesticides on non taget species and the ecosystem in Tanzania. The use of pesticides in Agriculture and other activities has increased rapidly in the past decades in developing countries following expansion of new areas of production and need to increase productivity per given area in order to meet demand to feed the increasing populations in developing countries. Although the largest quantities of pesticides are still consumed by western countries, many cases of pesticide poisoning occurred in developing countries. This is due to lack of knowledge on proper handling of pesticides, widespread ignorance of risks involved, lack of reinforcement of legislation governing pesticides and inadequate extension services especially in rural areas. Other factors are like lack or minimun use of full protective clothing, poor disporsal methods and mis handling of empty pesticides containers accounts for increased risks of pesticides poisoning to the agricultural workers, general public and the environmental pullution. The purpose of this review is to focus on health effects of pesticides that are used to control migrant agricultural pests to non target organisms and the ecosystem in Tanzania.

Key words: Ecosystem, health risks, migrant pests, non target species, Pesticides.

INTRODUCTION

Tanzania agricultural lands play a critical role in conserving biodiversity, since nearly half of her land is farmed (Kideghesho, 2013). Agricultural chemicals are considered as among factors that enhance crop productivity. However, pesticides are among important factors negatively affecting the human and animal health, environmental pollution, and biodiversity (Kisamo, 2002).

Although, several studies have been done on the impact of pesticides on environment, ecosystem and biodiversity in many parts of the world, there is inadequate information of risk hazards of chemicals to the Tanzanian environment (Ngowi et al. 2007). Most of the Sub-Saharan Africa still receives chemical donations from developed countries and there is a continuous damping of these chemicals in the environment without serious consideration on negative side on the biodiversity (WBG, 2013) In fact only less than one percent of the chemicals reach the target area and the rest is wasted to the environment and seriously affects human and other non-target organisms (Pimentel, 1991). All pesticides are poisons at different levels (Abby, 2002). All over the world Pesticides are used in agriculture to control pests such as insects, rodents, and weaver birds, fungi or nematodes and in public health for the control of harmful organisms and vectors (Damalas, 2011). The increasing demand for food can be mate either by farming in new areas, or by intensifying the use of existing agricultural areas by adoption of good agricultural practice including protection of crops from effects of pests and diseases. Intensification of existing agriculture is necessary as new areas are scarce (Gaba, 2014). Pesticide plays significant role in increasing agricultural productivity.

Besides these positive effects, they also have negative effects (Gilbert, 2014). Pesticides are poisonous to humans and animals when not used carefully.

Furthermore, they are detrimental to non target insects and animals that are potential predators to harmful agricultural ones, important plant pollinators and honey bees (EXTOXNET, 2006).

Migratory pests of agricultural importance in Tanzania

Migratory or transboundary pests are the pests causes serious damage outside their local habitat (Elliott, 2000). These pests are highly mobile and are able to freely traverse political boundaries, causing significant economic loss through devastations in Agricultural crops, making active co-operation between neighbouring countries with regard to monitoring, management, and control vitally important (Elliott, 2000). The common migratory pests of Agricultural importance in Tanzania are Armyworms, Red billed quelea birds, and Locusts as stipulated here under.

Armyworms

The African army worms *Spodoptera exempter* (walker) is one of the migrant pest of agricultural importance in Tanzania and the whole of Eastern Africa. They are the larva stage in the life cycle of the Noctuidae Lepidopterans moth (Grzywacd, 2008). The matured moths flies at night covering more than 100 km per night with the help of Inter tropical convergence zone winds (ITCZ) and after mating the females lay millions of eggs under the leaves of the young cereal plants while on transit, which eventually hatches after a short period of time when environmental conditions are conducive and start attacking crops. The caterpillars cause extensive damage to grazing land, cereals and sugar cane. Compared with locust outbreaks, armyworm infestations usually occur on a smaller scale but may extend over several hundred square kilometres. Outbreaks and movements are usually related to the rainy seasons (FAO, 2001)

Locusts

Locusts are probably the oldest migratory pest in the world. They are part of a large group of insects commonly called grasshoppers belonging to the family Acrididae (Symmons, 2001). They differ from ordinary grasshoppers in their ability to change behaviour (gregarize) and to migrate over large distances. There are two major types of grasshoppers of agricultural importance occurring mostly in Africa, Middle East and Asia. These include the Desert Locusts (*Schistocerca gregaria* (Forskal) and Red locust (*Nomadacris septemfasciata* (Symmons, (2001). Desert locust is among dozen species of short-horned grasshoppers (Acrididea) that are known to change their behavior and physiology in response to changes in population density by forming swarms of adults or bands of wingless nymphs called hoppers. It is usually solitary, but from time to time there is a population explosion and migrates in vast swarms in long mileage that cause extensive damage to crops (FAO, 2004). Desert locusts are the most damaging of the migratory pests. They have adapted to semi-arid or desert environments where rainfall is scarce and irregular but often torrential when it occurs. Normally, the desert occurs in desert and scrub regions of northern Africa, the Sahel region including the countries of Burkina Faso, Chad, Mali, Mauritania, and Niger, the Arabian Peninsula e.g., Saudi Arabia, Yemen, Oman, and parts of Asia to western India (Locusts Handbook, 1990).

This map was sourced from Desert locust in Africa and Asia, in Earth Observatory (EOS) Project Science Office, NASA –GSFC by Charles Ichoku.

Red locust is a large grasshopper compared to others found south of the Sahara in southern parts of Africa. Its name refers to the colour of its hindwings (Symons, 2001). When it forms swarms in gregarious phase it is described as a locust. The overall colour of adult insects is a mixture of light beige and brown. They have seven brown transversal bands on the elytra, justifying the species name *septemfasciata*. Outbreak areas have been identified in Zambia, Tanzania, Malawi and also Madagascar and Réunion (Spurgin, 1999). Tanzania is one of the first countries at risk as it harbours four out of the eight recognized Red Locust outbreak areas in Central and Southern Africa. Breeding areas in Tanzania where chemical control are intensively carried out almost every year includes, Wembere Plains in Tabora region, Malagarasi Basin in Kigoma region, Ikuu-Katavi Plains and Rukwa Valley in Rukwa region.

Distribution of red locusts

They feed mainly on grasses, like Echinochloa pyramidalis, Cynodon dactylon and several species of Cyperus species which have relatively soft and juicy leaves like. Many other plants are attacked during plagues, especially by adult swarms. Prominent among these are citrus and other fruit trees, Tobacco, palm trees, cotton, cassava and vegetables (Craig, 2010).

The red-billed quelea

The red-billed quelea *Quelea quelea* is a small weaver bird native to sub-Saharan Africa and renowned for its

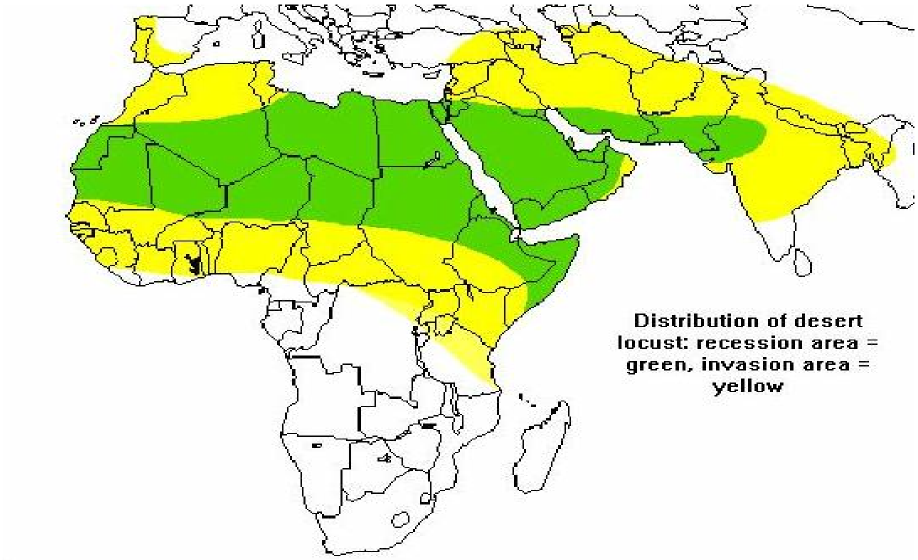

Figure 1. Map showing Desert locust areas of distribution, Recession and Invasion areas.

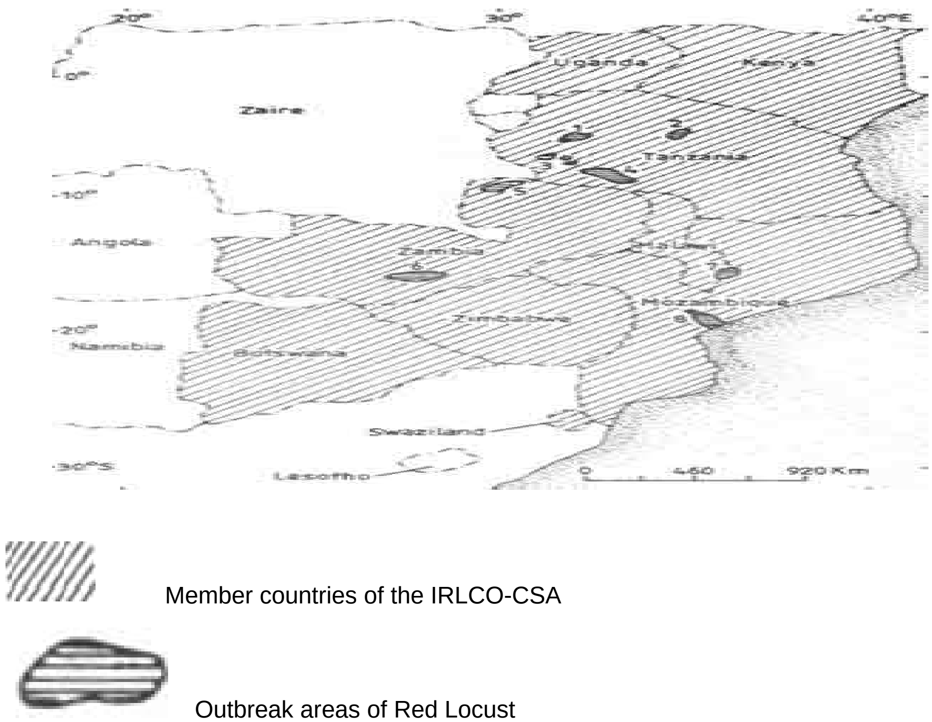

Figure 2. Outbreak and breeding areas of Red Locust in Eastern and Southern Africa. This map is courtesy of International Red Locusts Control Organization (IRLCO-CSA).

attacks on small-grain crops within Africa. It is the most numerous bird species in the world, with peak post-breeding population estimated at 1.5 billion (CABI, 2015).The red-billed quelea is mainly grainivorous, except when preparing for migration and during breeding season and when feeding its nestlings insects which are the good source of protein for growth or when eating insects prior to migration or breeding which help in wing muscle building for high flying and energy reserve ready for breeding (CABI, 2015). Migration is influenced by rainfall patterns that affect the availability of certain annual grass seeds, which are the staple food of this species. They migrate over distances of more than 1 000 km, consequently crossing political borders. Affected areas may lose most or all of their cereal crops (FAO 2001). A colony of more than 12,000 nests per hectare was estimated to have a monthly consumption of 1845 kg of seeds per hectare and 214 kg per hectare of insects (Craig, 2010). Quelea pairs breed up to three times a year. Their ability to migrate long distances in search of food and new breeding grounds makes quelea a particularly difficult pest to control.

Control of Migratory pests

The control of migratory pests raises the most obvious transboundary issues, as pest populations can expand quickly from a localized outbreak to an upsurge, with serious infestations occurring simultaneously in several areas and neighboring countries. (FAO, 2001) The fast initial multiplication may occur unnoticed in remote and unpopulated areas and follow a natural pathway. Once cropping areas are invaded, there is rarely sufficient time to prevent damage through control operations (FOA, 2001). The widespread destruction that can accompany an outbreak or swarm of migratory plant pests makes it a political imperative for many countries to attempt control. Control is carried out as a response to the appearance of migratory pests, with the main effort aimed at eradicating them once they appear in significant numbers. The primary response is widespread pesticide spraying in affected areas once these have been defined (FAO, 2001). In locusts control it has been estimated to cost more than US$ 40,000,000 for 2003-2005 up sages in desert locust affected countries (FAO, 2007). Dieldrin was the first insecticide used on a large scale for locust control during 1950s and is toxic on contact with the insects (John, 2010). Dieldrin and other Organochlorine insecticides are registered under Stockholm convention as Potential Organic Pollutants (POP) (Stockolm, 2004). They were eventually banned because of persistence, environmental effects, and bio-concentration in fatty tissues (Mark, 1998). Replacement insecticides included the organophosphate products like fenitrothion, malathion, diazinon, and the carbamates carbaryl (EXTOXNET 2006). These were less hazardous to the environment but more hazardous to human and animal health. They were followed by chemicals of the pyrethroid family including cypermethrin and lambda-cyhalothrin, and the new phenyl pyrazole fipronil. All these broad spectrum ‘knock-down’ chemicals are hazardous to non-target species, and must only be used on a clearly identified locust swarm target or a breeding site (Mark, 1998). Currently in Tanzania, Fenitrothion and Adonis (Fipronil) are Organophosphate pesticides in ultra low volume formulation which are the registered insecticides for aerial control of locusts in outbreak areas (Willoughby, 1999).

In red locust control, Fipronil, is probably not acceptable for the control of red locust in its outbreak areas because of its high toxicity to fish and aquatic invertebrates (Jackson et al, 2009). Red locusts have preference in habitats with flooding environment most of which are very close to water sources. In armyworms control, the most insecticides commonly used during outbreaks are those formulated in Emulsifiable concentrates (EC) (Fishel, 2013). The reason is that, application of such chemicals involves knapsack and other small manual spray pumps afforded by most farmers unlike ULVs which need motorized sprayers. When sprayed, this dilute emulsion gives a uniform and accurate application of active ingredient on the crop, which is essential for effective pest control (Roberts, 2013). The formulation active ingredient into an Emulsifiable concentrate can ensure uniform spreading and wetting under normal spray and weather conditions (Fishel, 2013). Most of these are registered organophosphates insecticides for broad spectrum use including Armyworm control (Roberts, 2013). In red billed quelea, the granivorous pest of agriculture have proved difficult to resolve due to large part of the behavioral versatility associated with their flocking ability as well as the array of food choices available to the flocking birds (Elliott, 1989). Based on these two factors, effective control is information intensive and therefore rather challenging. The control of migrant pests such as quelea in Tanzania is a major concern to most farmers and the Ministry of Agriculture and Food Security. Several non chemical techniques have been tried to reduce bird populations to levels where crop damage is minimal (Matee, 2000). Traditional methods including slings, bird scares, and scarecrows, are still being used in many parts of the continent. Modern techniques of frightening devices, for example the millar reflective tapes, chemical repellents, like naphthalene and capsaicin, are registered as bird repellents and can function as primary mammalian repellents (Larry, 1998). Others are like less preferred crop varieties such as Ark 3047 sorghum and alternative cultural practices like changing time of planting and irrigation have been evaluated by Tarimo, (1999). They are helpful at subsistence level where many farmers individually scare birds from small farm but in large scale farming they are not worthwhile. All the methods have minimal value in situations where bird pressure is high and where farm area is relatively large. Aerial spraying of pesticides (parathion and later fenthion) on nesting and roosting site is yet the most widely used technique to date (Nyanbo, 2009). Currently in Tanzania, only fenthion 60%ULV aerial formulation is being used. The pesticide is recommended to be used at the rate of 2l/ ha.

Pesticides use in Tanzania.

Pesticides can be divided in various categories according

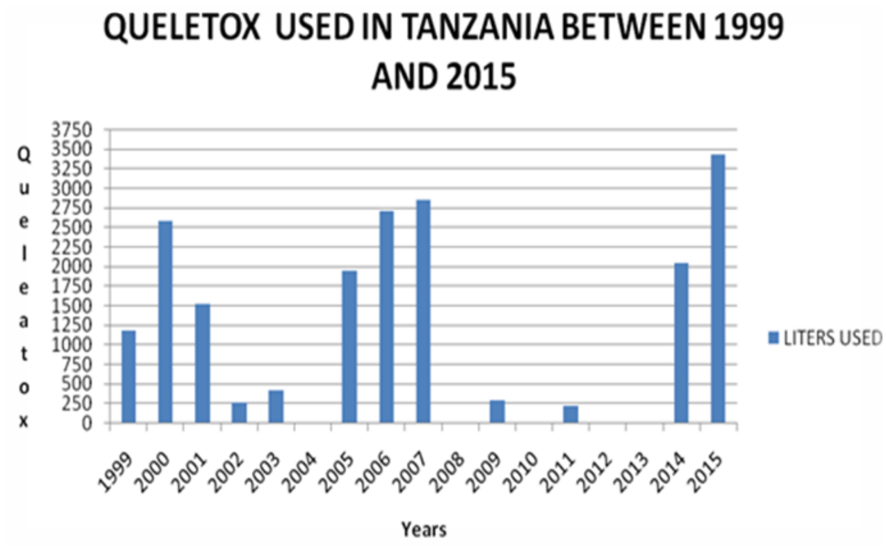

Figure 3. Queleatox used to control red billed quelea (*Quelea quelea*) for 15 years in Tanzania

to their target organism. Insecticides are used to control agricultural, medical, veterinary and household insect pests. This is the largest group of pesticides used in Tanzania (URT, 2011). Fungicides are used to control fungal diseases; Acaricides are used to control mites and veterinary parasites and herbicides for control weeds (WHO, 2009). Rodenticides for control of rats and other vertebrate vermins. This group and acaricides forms the second large quantity of pesticides used in Tanzania following frequently outbreaks of rats and large number of livestock forces demand of acaricides (URT, 2011). Nematicides are used to control nematodes. Avicides are chemicals used to control birds and Fumigants are pesticides in gaseous formulation which controls storage pests (WHO, 2009). All these have serious negative impacts in both non target organisms and ecosystem in general. Pesticides, particularly agro-chemicals in Tanzania are widely used to recoup agricultural crop yields that would otherwise been lost through the ravages of disease and insect pests (UNIDO, 2011). They are comparatively well defined agricultural innovations although some farmers may have little knowledge on the economic threshold (Zilberman, 1999). The pesticides use in agricultural production is important and their effect on yield can be substantial (Peniel et al. 2012). Most of pesticides used in Tanzania are imported either by government or private companies while others are given as grants. All activities related to Pesticides use in Tanzania are regulated by the Legislative act which was in acted by the national parliament of the United Republic of Tanzania in 1997 called Plant Protection Act 1997 and followed by regulations put in place on 1999. The overall objective of this act is to prevent the introduction and spread of Agricultural harmful organisms in the Tanzania (PPA, 1997). However, the adventure of free market trade and globalization, reinforcement of this act and its regulations remained a great challenge (Akh'buhaya, 1988). Nowadays, pesticides are freely sold in many shops and markets in town and in rural areas (Akh'buhaya, 1988). There are illegal importations which are practiced by traders to avoid fees, levies and taxes. There is no straight forward mechanism to dispose expired and old pesticides hence can lead to stockpile.

The other ground where pesticides are extensively used in Tanzania is in vegetable production. According to Ngowi et al. (2008) on the survey made in Northern Tanzania in Arusha and Kilimanjaro regions it was revealed that there is heavy pesticides application to vegetables mentioned tomatoes, cabbages and onion. Fifty nine percent of among types of pesticides used in this case were insecticides while 29% and 10% were fungicides and herbicides where others were rodenticides (Ngowi et al. 2008). About 34% of the farmers applied pesticides in mixtures following multiple attacks in the same crop by insects and diseases or because of resistance by both. Up to 90% had a cocktail of maximum of 3 pesticides in a mixture (Bouchard et al. 2010). Pesticides often contain inert ingredients in addition to the active ingredients that are designed to kill the target pest. Unfortunately, no information is available for the public about what inert ingredients are included in pesticides in most cases (Bouchard et al. 2010). In all cases there were no specific instructions either from the labels or extension workers regarding these tank mixtures about health and food safety, environmental pollution and creating disease or pest resistance. 53% of the farmers involved in this case reported that the trend of pesticide use was increasing (Ngowi et al. 2008).

Pesticides Health hazards to non target species

Pesticides have been linked to a wide range of human health hazards as one of the non target organism, ranging from short-term impacts such as headaches and nausea to chronic impacts like cancer, reproductive harm, and endocrine disruption (Aktar et al. 2009). Short term effects like skin, and eye irritation, headache, nerve damage, dizziness, nausea, fatigue, and systemic poisoning can sometimes be dramatic, occasionally may cause death (Lorenz, 2006). According to the World Health Organization estimation, there are 3 million cases of pesticide poisoning each year and up to 220,000 deaths, primarily in developing countries (Bertolote, 2008). The application of pesticides is often not very precise, and unintended exposures occur to non target organisms in the general area where pesticides are applied (Lorenz, 2006). Children, and indeed any young and developing organisms, are particularly vulnerable to the harmful effects of pesticides. Even very low levels of exposure during development may have adverse health effects (Sarwar, 2015).The toxicity of a substance is its capacity to cause injury to a living system. This can be categorized in to two types whereas acute toxicity is used to describe effects which appear promptly, or within 24 hours of exposure, while chronic toxicity of pesticides refers to long time effects after exposure and mostly concerns the general public, as well as those working directly with pesticides because of potential exposure to pesticides (Konradsen, 2007).

Pesticides have four (4) major routes of entry to the body of target and non-target organisms. Dermal or body contact is the major route of entry among others as many pesticides are manufactured to act and show required efficacy through this route (Mac Farlane et al. 2013). More than 95% of all exposures are dermal. Dermal absorption to non-target organism(s) especially human may occur as a result of a spill, splash or drift during mixing and loading of chemicals, during spraying and when cleaning or repairing equipment (Amalia, 2008). The second route of exposure to pesticides is inhalation. For many toxic chemicals, respiration system is the quickest and most direct route of entry in to circulatory system. Pesticides formulated in powder, gases, dusts, vapors and spray with very small droplets like micron air sprayers in aerial spray of Fenthion during quelea control can easily be inhaled (Mac Farlane, et al. 2013). Oral route follows the third route. Accidental oral exposure most frequently occurs when pesticides have been removed from the original container and put in to different unlabeled bottle or food container (Bertolote, 2008). Unfortunately, children are the most common victims of these situations. For other non target organisms like birds of prey, wild animals, pet animals, reptiles and human beings in this route also apply when they consume sprayed quelea birds by fenthion or other contaminated food material and water (Damalas, 2011). The last route is eyes which are very sensitive to many pesticides and are able to absorb large amounts of pesticides. Serious contamination may result from splash, spill or drift (Reigart, 2006). The likelihood of developing health effects depends on the type of pesticide and other chemicals that are in the product in use, as well as the amount exposed to and how often exposed (Damalas, 2011).

It has also been confirmed that pesticides can cause many types of cancer in humans. Some of the most prevalent forms include leukemia, lymphoma, brain, bone, breast, ovarian, prostate, testicular and liver cancers (Sharma et al. 2013). According to AmLorenza's Environmental Protection Agency (Jackson et al. 2009) fipronil is classified as "Group C- possible human carcinogen", based on increases in thyroid follicular cell tumors in rats in laboratory tests. It also warns that it is highly toxic to honeybees. Another disadvantage of fipronil, is that it is non-selective, so other animals are affected (EPA, 2009). There is also mounting evidence that exposure to pesticides disrupts the endocrine system, causing havoc with the complex regulation of hormones, the reproductive system, and embryonic development (Aktar et al. 2009). Endocrine disruption effects includes infertility and a variety of birth defects and developmental defects in offspring, including hormonal imbalance and incomplete sexual development, impaired brain development, behavioral disorders, and many others (Aktar et al. 2009). Other Non target species affected by pesticides include; birds of prey, insects and small animals directly affected when they are sprayed within target group (Mcwilliam, 2011).Wild bees, certain wasps, honey bees, and other insects are important pollinating agents of crops. Most pesticides are harmful to these pollinators, causing direct losses of the insect populations and indirect losses of crop yield because of the lack of adequate pollination (Jaffery, 2012). Beneficial organisms include various insects, nematodes, bacteria, mites, fungi and other microorganisms that feed on or parasitize pest species (Fishel, 2005). Soil organisms have responsibility to the decomposition of dead animal and plant material into organic matter, which is an important component of soil fertility (FAO, 2001). Others are involved in the natural control of soil pests. Despite of their direct effects on pest organisms, soil microbes plays major role in degrading pesticides.

The value of certain soil bacteria that have a symbiotic relationship with leguminous plants in fixing nitrogen have significant role into reduced synthetic nitrogen fertilizer inputs and increased crop yields (Fishel, 2005). Ecosystem contamination by pesticides poses a serious health threat to consumers of pastures, water from surface and ground sources, soil biology and air (Gupta, 2008). Continuous application of pesticides in the same localities could seriously harm the ecological balance of such areas and so there is a need to continue the search for much safer acridicides (Bahama, 1999). All this falls under adverse effects that would not be expected to occur. This signifies the need for more research to alternative methods to replace the use chemicals or chemical that is specific to a target and less detrimental to ecosystem (Mc william, 2011). We would like to completely avoid the use of lethal control and shift to non-lethal methods that could be user friend to the ecosystem.

CONCLUSION

Data on pesticides poisoning in Tanzania are limited. The launching of the economic recovery program and liberalization of trade in Tanzania has resulted in the rise of amount of pesticides imported into Tanzania. With the increase in population density, intensification in agriculture and opening of new farms, pesticides will remain important commodities to be used for the improvement of livestock production and mainly in agriculture for crop protection in Tanzania. Despite the establishment of regulatory framework to control pesticides trade in Tanzania still there are unscrupulous traders that conduct pesticides trade without being registered by regulatory institute. There are illegal importations which are practiced to avoid fees, levies and taxes. It is therefore difficult to trace and establish the correct amount and types of pesticides used in the country as a whole. Excessive use of pesticides, lack of enforcement of the legislation, widespread of ignorance of risks involved, lack of use of protective gears during application of pesticides and inadequate agricultural extension services, all accounts for increased risks of poisoning to farmers, agricultural workers, non target species and ecosystem in general. More research on health and environmental user friend pesticides is of great paramount. More education needed by farmers on better alternative control methods including IPM knowledge.

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