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Review

The status of research on and application of biopesticides in Tanzania. Review

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ABSTRACT

Increasing pest resurgence, negative effects on environment and biodiversity caused by synthetic pesticides and increased consumer demand for safe food have invigorated research on biopesticides. In Tanzania, the use of biological materials to protect crops against pests has a long history and there is a wide base of indigenous knowledge in the application of such materials in insect pest management. Moreover, research has identified a significant number of botanical materials with potency against various insect pests. Ironically, there are very few biopesticides which have been registered in Tanzania.

Here we review pertinent literature including relevant laws and regulations in order to establish the factors which have hampered legislative registration and commercialization of biopesticides in Tanzania. It is evident that some achievements have been attained by the indigenous people in using different types and forms of botanical materials in pest management, that have also been confirmed by research. These include Neem (*Azadirachta indica*), *Eucalyptus globules* leaf powder, Neem kernels, *Tephorosia vogelii*, *Euphorbia tirucalli* leaves and seeds, *Neurautanenia mitis* and *Pedilanthus cucullatus*.

The major reasons for the lack of registered and subsequently commercialized botanical pesticides in Tanzania are: (i) none of the research projects had any focus on product development and commercialization. They all focused on knowledge generation and training; (ii) lack of consistency and sustainability plans; (iii) the legal framework lacks a clear roadmap for development and commercialization of biopesticides, it is too bureaucratic and the total cost of registration is prohibitive.

This review therefore proposes research and development to focus on the identified botanicals with a view to optimize and formulate effective biopesticides. The laws governing pesticides need to be reviewed to provide a vivid road map for biopesticides research, development and commercialization. Laws/regulations governing business establishment should be harmonized to reduce the number of regulators and overlapping roles.

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1. Introduction

Preservation and protection of field crops is essential in order to reduce pre-and postharvest losses which, in countries like Tanzania, can be as high as 50% (De Lima, 1987; Paul et al., 2009). Infestation by stored product pests also causes loss of seed viability, as well as decreasing the quantity and quality of human food (Mushobozy et al., 2009) thereby contributing to malnutrition and famine. In addition, stored products pests cause severe loss of commercial and economic value of stored products and therefore dampen the farmers' efforts to reduce family poverty.

Production of mycotoxins by several fungi adds to the gravity of the problem. Fungi are significant destroyers of both crops in the field and the stored produce, retarding their nutritive value and rendering them unfit for human consumption through production of mycotoxins. According to FAO estimates, 25% of the world's food crops are contaminated with mycotoxins each year (Jelinek et al., 1988). A recent survey in three ecological zones in Tanzania revealed that maize produce is contaminated with aflatoxin and fumonisin at levels ranging from 0.1 to 269 μg/kg and 49–18273 μg/kg, respectively (Kamala et al., 2016). Aflatoxin (FB1) and deoxynivalenol were detected in urine samples from all adults and more than 96% of children in the study area (Gong et al., 2015). Prolonged dietary exposure to mycotoxins has been linked to cancer and kidney, liver, and immune-system diseases (Reddy et al., 2010). Mycotoxins contamination of foods occurs more frequently under tropical conditions where diets mainly constitute of crops susceptible to mycotoxins' contamination. Key environmental factors such as temperature, water availability and gas composition influence both the rate of fungal spoilage and formation of mycotoxins (Magan et al., 2003). Poor harvesting practices, improper storage, and sub optimal conditions during transport and marketing can also contribute to fungal growth and production of mycotoxins (Duarte et al., 2010; Dubey et al., 2008; Miller, 1995).

Application of synthetic pesticides and fungicides has been the sole effective solution for insect pests, fungal infestations of crops and crop produce for a long time. However, the use of synthetic pesticides and fungicides face a number of challenges including genetic resistance of insect species, pest resurgence, residual toxicity, phototoxicity, vertebrate toxicity as well as widespread environmental hazards.

There have been concerns raised by environmental conservationists and human rights activists about pesticide residues in soil and aquatic environment especially in vegetable farming areas in Tanzania. Consequently, some studies were conducted from 2000 to 2014 to assess the magnitude of pesticides pollution in various regions in Tanzania. In these studies it was revealed that, levels of contamination of soil and water varied from place to place. These variations were attributed to the intensity of farming activities, forms of pesticide applied, the rate of pesticide usage on farms as well as the knowledge of famers on pesticides handling.

A study of organo-chlorinated pesticide residues in tomato field soils at Ngarenanyuki in Arumeru, Arusha region Kihampa et al. (2010) found low levels of soil contamination. However concern was raised due to the fact that the soils could lead to bioaccumulation of pesticides in the subsequent plants. Pesticide residues such as DDT in water sources were in higher concentrations during the wet season than in the dry season (Hellar and Kishimba, 2009) and this was attributed to the usage of the pesticide in agricultural and horticultural fields.

Chlorinated chemical pesticides may remain in the environment for a long time and may have long term negative effects to the environment and ecosystems. For instance, a study conducted at a collapsed pesticide storage shed at Vikuge farm in Kibaha (Coastal region) in Tanzania, found that soil was contaminated with DDT and HCHs at soil depths down to 50 cm. Surface soil samples contained up to 28% total DDT and 6% total HCH residues. Water samples had concentrations of up to 30 ppm of organochlorine pesticides (Elfvendahl et al., 2004). Consequently the soil was deemed hazardous waste and a potential environmental and health risk. Another study on a large number of expired chemicals at the Old Korogwe DDT site (Kihampa and Mato, 2009) disclosed the potential of the organochlorine pesticides to leak and contaminate the environment and enter the food chain. These studies exposed the weakness of regulatory enforcement and hence a need for review of the same.

Furthermore, a survey study conducted by the Tanzania Industrial Research and Development Organization in 2007 (unpublished) in Lushoto district divulged that application of synthetic pesticides during vegetable cultivation had led to serious contamination of soil and water bodies (rivers). For example the level of *pp*'-DDT in water and sediment samples was in the range of 2.4–2.8 g/Kg and 170–1154 g/Kg respectively, whereas the total endosulfan concentration in water and sediment samples was in the range of 0.44–0.84 g/Kg and 0.062–1.25 g/Kg, respectively. Fenitrothion concentrations in water and sediment samples were in the range of 1.4–1.8 g/Kg and 0.427–0.975 g/Kg, respectively. These levels, especially in river water, exceeded the permissible levels set by WHO for drinking water which are 1–2 g/kg. These rivers are the main sources of water for domestic usage and residents of these areas may therefore be subjected to serious health consequences. Since vegetable farming is the sole means of livelihood for these communities, control of these sources of contamination of water and soil is difficult. The use of biopesticides in vegetable cultivation in these areas could mitigate the risks to these communities.

These challenges coupled with increasing costs of application and use of synthetic pesticides as well as increased consumer demand of organic products have created the impetus to search for safer, effective and biodegradable pesticides. Pesticides derived from natural materials referred to as biological or biopesticides have attracted tremendous interest as they are eco-friendly. These can be an alternative to synthetic pesticides for pest management. Although there has been considerable research and development on biopesticides, a few have been commercialized in the USA, Europe, Latin and South America, fewer in Asia (Dutta, 2015; Glare et al., 2012; Thakore, 2006) and almost none in Africa. Paradoxically, African natives for a long time have been using plants and plant extracts to mitigate pests (Isman, 2008). This indigenous knowledge and experience could be tapped to accelerate