Crop Protection 108 (2018) 71–77

Contents lists available at ScienceDirect

Crop Protection

journal homepage: www.elsevier.com/locate/cropro

Environmental load of pesticides used in conventional sugarcane production in Malawi

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ARTICLE INFO

Keywords:
Sugarcane
Pesticides exposure
Environmental load
EIQ

ABSTRACT

The sugarcane industry is the third largest user of pesticides in Malawi. Our aim with this study was to document pesticide use and handling practices that influence pesticide exposure among sugarcane farmers in Malawi. A semi-structured questionnaire was administered to 55 purposively selected sugarcane farmers and 7 key informants representing 1474 farmers in Nkhata Bay, Nkhotakota and Chikwawa Districts in Malawi. Our results indicate that herbicides and insecticides were widely used. Fifteen moderately and one extremely hazardous pesticide, based on World Health Organization (WHO) classification, were in use. Several of these pesticides: ametryn, acetochlor, monosodium methylarsonate and profenofos are not approved in the European Union because of their toxicity to terrestrial and aquatic life, and/or persistence in water and soil. Farmers (95%) knew that pesticides could enter the human body through the skin, nose (53%) and mouth (42%). They knew that pesticide runoff (80%) and leaching (100%) lead to contamination of water wells. However, this knowledge was not enough to motivate them to take precautionary measures to reduce pesticide exposure. Farmers (78%) had experienced skin irritation, 67% had headache, coughing and running nose during pesticide handling. Measures are in place to reduce pesticide exposure in the large estates and farms operated by farmer associations. Smallholder farmers acting independently do not have the resources and capacity to minimize their exposure to pesticides. There is need to put in place pesticide residue monitoring programs and farmer education on commercial sugarcane production and safe pesticide use as ways of reducing pesticide exposure.

1. Introduction

Sugarcane is the second most valuable crop after tobacco contributing 9–12% of Malawi's foreign exchange earnings (FAO, 2015). In 2017, large estates contributed 83% to national production compared to 17% for smallholder farmers (ILLOVO, 2017). The Government of Malawi supports smallholder production of sugarcane as a sustainable way of reducing poverty (Chinsinga, 2017). Hence, the number of smallholder sugarcane famers also known as outgrowers has been increasing since 2011. However, since 2014, the amount of sugarcane processed at sugar mills from smallholder farmers has been decreasing while it has remained constant for the estates (ILLOVO, 2017). There are many contributing factors to the low sugarcane tonnage by smallholder farmers. Pest occurrence and poor crop management may be some of the factors (Tena et al., 2016).

Pesticides are widely used throughout the sugar industry. The industry consumes 10–15% of pesticides imported in Malawi (GOM, 2017). Herbicides recommended for use in sugarcane production in Malawi include ametryn, atrazine, monosodium methylarsonate (MSMA), 2-methyl-4-chlorophenoxyacetic acid (MCPA), s-metolachlor, pendimethalin, diuron, acetochlor and glyphosate (GOM, 2017; Agricane, 2011). Glyphosate is a pre-emergent herbicide for the control of emerged annual and perennial weeds, and for crop/ratoon eradication. It is a recommendation that farmers apply glyphosate when the land is lying in fallow. Atrazine and pendimethalin are also pre-emergent herbicides for the control of annual broadleaf and some grass weeds. Application of these herbicides is at the time of planting/rattooning and before weed emergence. Ametryn and MSMA are post-emergent herbicides for control of most annual and broadleaf weeds. Some herbicides such as acetochlor, atrazine and glyphosate are both pre -and post-emergent herbicides. Several insecticides including chlorpyrifos and profenofos have government approval (GOM, 2017).

The undesirable effects of pesticides on the environment and human health are widely recognized. Pesticides can pollute the environment through pesticide runoff, drift, leaching and bioaccumulation (Mostafalou and Abdollahi, 2013; Wang et al., 2011; Weichenthal et al., 2010). The pesticide dichlorvos is an organophosphate fumigant pesticide that has no approval in the European Union (EU). It is highly

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https://doi.org/10.1016/j.cropro.2018.02.012
Received 9 October 2017; Received in revised form 16 January 2018; Accepted 8 February 2018
0261-2194/

toxic, has a high tendency to bioaccumulate (PPDB, 2017). Even though glyphosate is considered to have low mammalian toxicity (Tarazona et al., 2017), its intensive use leads to groundwater contamination, herbicide resistance and inhibition of plant growth (Cederlund, 2017; Schryver et al., 2017; Van Stempvoort et al., 2016). Glyphosate is highly discussed in the EU because of possible carcinogenetic potential (EC, 2017). Glyphosate has approval for use in the EU until 2022 (PPDB, 2017).

The Government of Malawi acknowledges that pollution of waterbodies, air, soil and food due improper handling, storage and disposal of pesticides is of high concern (GoM, 2010). Hence, there are laws and policies for regulating pesticides. The Pesticides Act No. 12 of 2000 regulates the management of import, export, manufacture, distribution, storage, disposal and use of pesticides in Malawi (GoM, 2001). The integrated pest management plan (IPM) set in 2013 seeks to promote the use of environmentally friendly practices in major crops (GOM, 2017). IPM 'means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms' (EU Directive 2009/128/EC). Only pesticides with the least potential for environmental contamination can be included in IPM programs (FAO, 2014). The major problem in implementing successful IPM programs in Malawi is a lack of, or insufficient data on environmental pesticides load – toxicity resulting from pesticides. Hence, the main objectives of this work were to determine the environmental and health effects associated with pesticides used in sugarcane production in Malawi.

2. Materials and methods

2.1. Sugarcane production in Malawi

Sugarcane is vegetatively propagated using cane setts (stem cutting having 3–6 internodes). The recommended seed cane rate is 8–10 ton per hectare. Row spacing for irrigated sugarcane is 1.5 m and 1.0 m for rain fed cane. Either 1.5 or double cane setts are planted end-to-end in furrow. The initial sugarcane planted is plant cane and the subsequent crop arising from remnants of harvest of this initial crop is ratoon cane. Herbicides are applied on a calendar basis. Insecticides and acaricides are applied based on action thresholds. Fields are allowed to dry for 30 days before being burned and manually harvested. The act of burning sugarcane concentrates sucrose and drives away snakes and crocodiles.

There is a sugar mill at Dwangwa Estate in Nkhotakota and in Nchalo Estate in Chikwawa owned by ILLOVO Sugar Malawi Limited. Associated with these mills are smallholder farmers growing rainfed or irrigated sugarcane on contracts. These farmers acquire farm inputs on credit from registered farmer associations (Agricane, 2011). It is important to note that some associations perform agricultural operations such as herbicide applications, and pest and disease scouting on behalf of their members at a cost. In some associations, the farmer has the liberty of carrying out all the farm activities himself. These differences have consequences on farm practices among the various smallholder farmers.

2.2. Description of study sites

In Malawi, sugarcane is intensively cultivated in the Nkhata Bay, Nkhotakota, and Salima and Chikwawa districts (Fig. 1). The Nkhata Bay and Nkhotakota districts are high altitude areas with average annual rainfall of 1490 mm received mostly between December and April. The crop is rainfed in Nkhata Bay. The major source of irrigation to the sugar industry in Nkhotakota is Dwangwa River that drains into Lake Malawi. Chikwawa is a low altitude area (< 150 masl) with half of the average rainfall received in Nkhotakota. Water is drawn from the Shire River that flows out of Lake Malawi. Because of the topography of Chikwawa, the district is prone to annual flooding from water movement from the Shire Highlands and groundwater discharge into the river (Meyer and Heathman, 2015). In addition to sugarcane, many agricultural activities involving the use of pesticides take place on the catchments of the Dwangwa and Shire rivers, and Lake Malawi.

2.3. Study population

We conducted the survey between June 2015 and January 2016 in Nkhata Bay, Nkhotakota and Chikwawa (Fig. 1). We used purposive sampling to identify respondents from association membership lists and/or with the help of local agricultural extension officers. As of 2015, there were 2039 registered smallholder sugarcane farmers belonging to 18 associations in Malawi. Only farmers belonging to associations who had applied pesticides themselves during 2014/15 were included in the survey. We also interviewed the farm/section/estate/agriculture managers for Dwangwa and Nchalo Estates; Kabadwa Cane Growers Association, Dwangwa Smallholder Cane Growers Association and Independent Cane Growers in Nkhotakota; Limphasa Sugar Corporation Limited in Nkhata Bay; and Kasinthula Cane Growers' Association in Chikwawa. These represented 1474 smallholder farmers and served as key informants. A pre-coded and pre-tested semi-structured questionnaire was interviewer-administered to capture information practices and knowledge related to pesticides. 'Yes' and 'No' were the allowable responses to closed questions. There were also questions with four to six factors per question and respondents were required to choose the most important. Respondents were politely requested to provide their demographic details, pesticide application history and the source of money used for buying pesticides.

2.4. Sugarcane pests and pesticides used to control pests

During the above-described interviews, farmers were requested to give information on incidence and severity of pests on their sugarcane farms. Another question required the farmers to rank the pests in order of importance. A pesticide knowledge section of the questionnaire collected information on whether the farmers knew the names of recommended pesticides, their application rates (quantity of pesticide mixed a specific water volume in a sprayer) and frequency. A series of closed questions helped the interviewer to capture data on type and timing of pesticide application. The questionnaire had questions also on effectiveness of the pesticides they have used.

2.5. Environmental pesticide load

Except in commercial estates, the majority of farmers in Malawi do not keep pesticides records (Tebug et al., 2012). This limited our choice of pesticide risk assessment models. Therefore, environmental pesticide load was determined using the environmental impact quotient (EIQ) model. The EIQ model is easier to use and requires only a few input data. The EIQ model is widely used for comparing different pesticide strategies and the environmental impact of pesticides used in agriculture (Kromann et al., 2011; FAO, 2008; Eklo et al., 2003). The EIQ model summarizes all pesticides used during the season, thus giving a total score for the environmental load (Kovach et al., 1992). Pesticide data: active ingredients (a.i.) quantity (in grams, g), application rates (g.a.i.) per hectare (ha) obtained from the questionnaire survey was entered into the EIQ model. Pesticide data pertaining to farmers who could not remember the quantities of pesticides they had used in 2014/15 were excluded in the calculation of environmental load. We used the online EIQ calculator on the Cornell University website (NYSIPM, 2017). In the online calculator, the application rate was given in g.a.i