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# The Use of Pesticides in Tomato Production: Exposition of Chokwe Farmers - Mozambique

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**Abstract** – Tomato is used for consumption and as a source of income for many Mozambican people. The present study aims to evaluate the level of intensity of the exposure of tomato growers of Chokwe to pesticides. For this purpose, 40 production units were selected, whose owners or their representatives and representatives of associations were interviewed. The levels of intensity of occupational exposure of farmers to the pesticides were calculated. It was found that tomato growers at Chokwe Irrigation system are subject to a high level of exposure to pesticides, which may pose a threat to health and lead to loss of life. Therefore, they are not sufficiently trained for efficient and safe handling of pesticides, apart from not having a full KIT of Personal Protective Equipment (PPE). Their perception of pesticides is limited and strongly related to the availability of training by government and non-government extension agents. So, there is a need to make accessible the use of PPE by tomato growers and to train them in viable pesticide application technologies.

**Keywords** – Environment Contamination, Safety at Work, EPI, *S. lycopersicum*.

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## I. INTRODUCTION

Agriculture is one of the most important economic activities in Mozambique, contributing to about 24% of the GDP and employing about 75% of its economically active population [1]. Most of this population lives and works in rural areas. Tomato (*Solanum lycopersicum* L.) is one of the most consumed vegetables in the world, as a fruit and a processed product. World and Mozambican productivity are respectively 59 and 22 tons per hectare (ha) [2]. Annual production in this country in 2016 was about 374000 tons in 17000 ha.

It is one of the most important crops produced and consumed in Mozambique, even though its production is among the lowest in the world [3]. The production is carried out along the river banks, mostly on smallholder farms, up to 3 ha [4], [5], [6].

Due to its recognized richness in vitamins and minerals, tomatoes have the potential to help reduce malnutrition levels in that country. On the other hand, the crop is used as a source of income for a large rural population, thus contributing to the alleviation of poverty through the acquisition of other essential goods and services from the income from marketing tomatoes. Therefore, it is a crop that, while not being produced at its maximum capacity, adds value to various segments of society.

The perimeter of the Chokwe irrigation system is one of the largest food production centers in Southern Mozambique, contributing much of the country's marketed and consumed crops, with tomatoes being the most important crop. The irrigation system is occupied by 12313 small and medium farmers who practice individual or associated farming, dedicated to the production of maize, rice, and vegetables [7]. However, tomato production is highly dependent on the use of agrichemicals, substances harmful to the environment and human health.

Pesticides are substances designed to prevent and control pests, including vectors that cause loss or interfere w

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-ith food production. Besides, the research relates exposure to pesticides to the occurrence of diseases such as leukemia in children [8], damage in the acoustic system [9], deleterious effects on seminal parameters [10] and to a weak cognitive development [11]. In Mozambique, official reports about pesticide use, point to significant growth [12], [13]. This growing adherence to the pesticide market is not being followed by risk evaluation to people and ecosystems.

The National Environmental Policy of Mozambique, approved by resolution 5/95 of 3 August 1995, defines, among several objectives and functions, the need to regularly produce information on the state of the environment. Environment constitutional protection was significantly empowered by the 2004 Fundamental Law, which emphasizes the fundamental right of all citizens to a balanced environment and the public interest in its protection. The first comprehensive report, approved in May 2011, does not present the environmental impact assessment of pesticide use, which is a weakness [16].

The administration of pesticides is carried out by seasonal workers in rural areas, mostly men with low education and little or no training. The preparation of the syrup is made using large amounts of pesticides and the frequency of application higher than recommended in the package insert. Besides, the disposal of the packaging is not always done correctly, being visible along the margins of the production area, empty packaging of the products used.

In general, the most commonly applied pesticides in Chokwe, namely cypermethrin, mancozeb, and methamidophos, have medium to high toxicity. Methamidophos is already banned in countries such as Brazil [17].

The use of highly toxic and not selective pesticides brings drastic consequences as the intoxication of people and domestic animals, environmental pollution and reduction of soil biota [18], [19]. In Chokwe, there are reports of occurrences of intoxication due to ingestion and inhalation of vapor, skin irritations, and contaminated water due to the inappropriate use of pesticides in agriculture. However, there are no specific studies related to the impact of the use of pesticides on human health and the environment. Therefore, the present study aims to evaluate the level of exposure intensity of Chokwe tomato growers to pesticides.

## II. MATERIAL AND METHODS

The study was carried out in the district of Chokwe, (latitude 24°31'51" S, longitude 32°59'48" L and 32 m of altitude). The climate is hot semi-arid (BSh), characterized by 662 mm of average annual rainfall, 23.7 °C of temperature, and 60-65% of relative humidity. The district is crossed by the Limpopo River, which supplies water for the largest irrigation system in the country [20].

Data were collected in two steps. The first consisted of a diagnostic study using semi-structured interviews involving local authorities, extension agents, farmers' associations and public agricultural services. At this step, the objective was to collect supporting information for the implementation of the questionnaire. The second step consisted of interviewing tomato growers in the irrigated Chokwe area. Before the study, an agreement was signed by farmers, preceded by permission from the local government.

For the sampling, 409 tomato growers along the irrigated perimeter were considered, in which small and medium farmers production units along the irrigated perimeter were identified. They were randomly listed, and 40 farmers were selected for the interview.



The interviews were based on a semi-structured questionnaire. This allowed the obtaining of information regarding the socio-economic profile of the producer, the level of access and use of pesticides, knowledge of application technologies, personal protective equipment (PPE), and the perception of risk associated with the administration of pesticides.

The questionnaire was administered between March and April of 2018 in the respective production units, on the day of administration of pesticides to the crops.

The level of occupational exposure intensity of farmers to pesticides was calculated using the algorithm described by [21], which combines ten variables that characterize the use of pesticides, as shown in the expression:

$$IL = [(Mix * Enclosed) + (Appl * Cab) + Repair + Wash] * PPE * Repl * Hyg * Spill$$

*IL* being the - level of occupational exposure intensity; *Mix* - refers to the realization of mixing of the products; *Enclosed* - type of system (open or closed) used for mixing; *Appl* - application method used; *Cab* - corresponds to the use of tractor with closed cabin or coal filter; *Repair* - is the state of repair of equipment; *Wash* - referring to washing equipment; *PPE* - personal protective equipment used; *Repl* - referring to the use of old gloves; *Hyg* - state of personal hygiene and *Spill* - related to attitude after spillage of pesticide on their clothing. Each practice developed by the producer in relation to each variable received value or weight that allowed the final calculation of occupational exposure.

The results of the occupational exposure were expressed qualitatively and quantitatively. Values of exposure levels between 0 and 10 represent the very low category; 11 to 20 for the low category; 21 to 30 intermediate, 31 to 40 higher and greater than 40 very high. This algorithm was based on the information provided by farmers regarding the use of pesticides and did not consider the toxicity potential or the hazard of the product in the environment. The perception assessment of farmers was adapted from a model of cervical cancer prevention [22]. The adjusted grading scale comprised: 1 - Suitable - when the farmers indicated 4 correct answers between a) Pesticides preparation and application procedures, b) Verification of pesticides validity, c) Procedures for PPE clothing d) Procedures after pesticide application and e) Destiny of empty pesticide containers, otherwise it was considered, 2 - not suitable. The data were analysed in the statistical package SPSS version 25 and the results presented in percentages. The Chi-square test at 1 and 5% probability was applied to assess the significance of the answers.

### III. RESULTS AND DISCUSSION

A large part of Chokwe tomato farmers does not have a complete Secondary School (Table 1). Schools are mostly located in urban centres, far from rural communities. Roads are difficult to access, and transport systems are lacking. As stated in previous studies, premature marriages can be related to an unsuccessful conclusion of secondary school [23], [24]. In Mozambique, the secondary School is concluded in about 10 years without failing. In urban areas, it normally happens between 15 and 16 years old, while in rural areas such as Chokwe, it is common to find people in this age group, married, mainly females.

Traditional agriculture constitutes the most used production system. Most of the interviews (95%) explore up to 5 ha of land, with production sold locally and in urban neighbouring markets (Table 1).

The land is not a limiting factor for farmers. What limits the cultivation in large areas is the cost associated with production. Farmers rent tractors and implements for their crops. The high-yielding seeds are imported from



neighbouring South Africa or bought in national urban centres at prohibitive prices. In addition, fertilizer prices are high. Thus, these limitations induce cultivation in small areas.

The intervention of the government in terms of support to farmers has been through rural extension services, access to bank loans and seed donations. Thus, the incentives have not been meaningful because of the demand of farmers and the limitation of resources. Based on the data obtained from the study, out of a universe of 40 tomato farmers interviewed, only a restricted group of 4 farmers have adequate technical and financial support from the Mozambican government.

Table 1. Socioeconomic background of tomato producers interviewed in Chokwe.

Questions	Possible answers	Percentage (%)	X <sup>2</sup>
	Illiterate	15	32,000 <sup>a</sup>
	Incomplete Secondary School	55	
Level of education	Complete secondary School	15	
	High School	10	
	Other	5	
Sex	Masculine	75	10,000 <sup>a</sup>
	Feminine	25	
	Less than 18	2,5	25,800 <sup>a</sup>
Age (years)	18 to 35	45	
	35 to 50	45	
	Over 50	7,5	
	Up to 1	35	9,600 <sup>b</sup>
Production area (ha)	1 to 3	35	
	3 to 5	25	
	More than 5	5	
The purpose of production	Consumption	15	7,400 <sup>b</sup>
	Sales	50	
	Consumption and sales	35	

Significant at <sup>a</sup>1%, <sup>b</sup>5%

A significant part of farmers (97, 5%) uses pesticides in their tomato crops. This way, 82, 5% of interviewees affirmed to have applied pesticides in all their farming season, while 15% administered in some crops. The main pesticides used are Mancozeb, Cypermethrin and Methamidophos administered as a mixture (table 2). The use of these pesticides by Mozambican farmers on crops is very common. In a study conducted in Chibuto District, about



the exposure of farmers to pesticides, reported high use of the same pesticides mentioned in this research [25]. These pesticides have medium to high toxicity, which, when applied without proper care cause health problems in humans [26], toxicity in pollinating agents [27], [28], toxicity in domestic animals [19], contamination of water resources [18], among others.

The establishment of standard regulation practices and management of pesticide use are alternative methods to prevent adverse effects of pesticide residues in the environment. In Chokwe there are no regulations concerning the use of pesticides, or if there are, they are not functional. It was found in this study that the acquisition and use of pesticides is the entire responsibility of farmers. Thus, since most farmers do not have training on the handling of these products, risks associated with misuse are higher (Table 2).

It's true that to produce food on a large scale, conscious use of pesticides is important in integrated pest management, in order to avoid production losses. In this strategy, the chemical control can only be administered after the application of all available methods of control, to avoid toxicological problems to both humans and the environment.

Besides the chemical control, in Chokwe, no alternative methods of pest control were observed. Some farmers do not use pesticides due to the lack of financial resources to purchase them.

Mixing pesticides in a tank are a common practice in Chokwe (92, 5%). It was observed that in 35% of the cases only two products are mixed, and in 57, 5% of the cases, three or more products are mixed. According to [29], mixing products in a tank is an international practice supported by the results of research studies. Nevertheless, dosages, mixed products, and crops should be considered. This approach is less observed in Chokwe since 72.5% of the respondents do not have the availability of agronomic revenue when purchasing pesticides and 67.5% are not aware of the techniques for preparation and application of pesticides (Table 2).

The poorly constituted mixture reflects on problems associated with decanting and formation of granules or pastes, adherence of products to the walls, filters, and sprayer hoses. The chemical quality of the water is another factor that must be analysed before the mixture, owing to the number of other ions which compose it, and which are not constituents of the hardness. For example, ions such as  $Fe^{+3}$  and  $Al^{+3}$  can react with the pesticide, reducing its effectiveness [30].

Considering Mozambican reality, most Chokwe farmers utilize coastal sprayers (85%). Nevertheless, it was verified that only 32.5% of the respondents know pesticide application techniques, which shows the poor training of farmers (30%). Point out that the efficiency of spraying depends in part on the level of training of pesticide applicators [31].

Table 2. Level of access, training, and use of technologies of application of pesticides by Chokwe Irrigation system tomato.

Questions asked	Response options	Percentage (%)	X <sup>2</sup>
Use of pesticides in Tomato cultivation	Never	2,5	44,450 <sup>a</sup>
	Sometimes	15	
	Always	82,5	
Training of pesticide	Yes	30	6,400 <sup>b</sup>



Applicators	No	70	
4			
Combinations of	Do not mix	7,5	15,050 <sup>a</sup>
Pesticides used	Mix two pesticides	35	
	Mix more than to pesticide	57,5	
Agricultural revenue	Never	72,5	27,950 <sup>a</sup>
availability in the	Sometimes	17,5	
acquisition of pesticides	Always	10	
Verification of pesticides	Never	10	21,950 <sup>a</sup>
Validity	Sometimes	22,5	
	Always	67,5	
Knowledge of			
Preparation	Aware	32,5	4,900 <sup>a</sup>
and application	Not aware	67,5	
Techniques			
Spraying	Do not have	2,5	22,500 <sup>a</sup>
	Coastal	85	
Equipment	Tractor couplings	12,5	

Significant at <sup>a</sup>1%, <sup>b</sup>5%

The largest destination of empty containers is reused (45%), followed by burning (25%), bury (15%) and disposal in the environment (15%) (Table 3). However, the destination given is not the most appropriate because it contributes to environmental contamination. The high rate of empty container reuse can be explained by the need of 5-liter capacity containers, common on insecticide Cypermethrin distribution. These containers are reused to bring water from the river, wells and storage of water for home use. This procedure contributes to increasing environmental pollution, human and animal intoxication.

According to Decree no. 6/2009 of March 31, 2009, from the Republic of Mozambique, empty containers must not be reused to contain any kind of human or animal food and water and must only be reused by the maker or dealer for the packaging of new products. However, the destination of pesticide empty containers reveals a lack of inspection and of public policy of reverse logistics for packaging, including the obligation to return empty containers to the pesticide dealer.

There is little use of PPE in Chokwe. Farmers interviewed are aware of the need to use PPE during pesticide a



-dministration to avoid direct contact with products. However, only 5% of respondents have full PPE and 85% have at least one PPE, with rubber boots and gloves standing out as the most used lot elements (Table 3). The importance of PPE's in the protection of pesticide administrators is consensual [32], [33], [34]. Though, lack of resources and misperceptions limit the widespread use of PPE, exposing the administrators to risks.

Table 3. Destination of pesticide empty packages and the use of individual protective equipment.

Questions asked	Response options	Percentage (%)	X <sup>2</sup>
	Dump in the environment	15	9,600 <sup>b</sup>
Destination of an empty container of Pesticides	Bury	15	
	Burn	25	
	Reuse	45	
Use at least one piece of PPE	Yes	85	19,600 <sup>a</sup>
	No	15	
Use half PPE	Yes	27,5	8,100 <sup>a</sup>
	No	72,5	
Use Complete PPE	Yes	5	32,400 <sup>a</sup>
	No	95	

Significant at <sup>a</sup>1%, <sup>b</sup>5%

The interviewed farmers who administered pesticides, mix their clothes with others when washing (72.5%). After the pesticide application, 67.5% take a bath and 55% change clothes. These data show the need to clarify and raise awareness among workers through courses and workshops on the risks of exposure to pesticides. Employees were asked to mark the signs and symptoms identified within 24 hours after contact with pesticides. Among the respondents, 57.5% reported presenting signs and symptoms such as skin irritation, nausea, vomiting, abdominal cramps, dizziness, generalized weakness, increased salivation and sweating, cardiac arrhythmias and respiratory failure (Table 4). Continuous exposure to pesticides may lead to cancer or neurological disorders and may ultimately cause death [35].

Within the study of social-environmental risk assessment of the use of pesticides, one of the factors that are relevant for the analysis and which leads to unsafe utilization of these substances is the level of farmers' education, since this is a basic element for understanding instructions in the package insert of product. The ability to read and interpret individual information regarding instructions for the use of pesticides is necessary. It was observed that in Chokwe, the use of one native language Xichangana (mother tongue other than Portuguese) for communication was dominant. An individual who has not completed elementary education, and speaks Xichangana will have difficulty reading, interpreting and understanding the information contained in the pesticide packaging labels written in the Portuguese language, which is not his domain.



Table 4. Farmers' perception of the practices and risks associated with pesticide management at the Chokwe irrigation system.

Questions asked	Response options	Percentage (%)	X <sup>2</sup>
Treatment of clothing after	Wash separately	27,5	8,100 <sup>a</sup>
Pesticide application	Wash mixed with other clothes	72,5	
Changing clothes after	Yes	55	0,400 <sup>NS</sup>
Pesticide application	No	45	
Bathing after pesticides	Yes	67,5	4,900 <sup>b</sup>
Application	No	32,5	
Declared symptoms related	Yes	57,5	0,900 <sup>NS</sup>
To the use of pesticides	No	42,5	

Significant at <sup>a</sup>1%, <sup>b</sup>5% and <sup>NS</sup> Not significant.

Obtained in this study show that the high category was dominant with 57.5%, followed by an intermediate category with 35% and low with 7.5%. The insufficiency of PPE, poor of lack of training and technical guidelines for working with pesticides and hygienic habits after the application of pesticides, are pointed as the principal causes for high levels of exposure to pesticides by the applicators in Chokwe. Therefore, given this scenario, there is a need for practical intervention of the public sector, through programs to monitor the use of pesticides.

#### *Determinants of Perception on Pesticides*

The perception of pesticides was strongly related to the availability of training on pesticide application techniques (Cof. = 2.813, Pvalue = 0.05). The results show that almost all farmers' perception about pesticides is transmitted in training processes that are given mainly by Agricultural Public extension services and some non-government organizations. Farmer's gender, level of education, age (years), use (or not) of pesticides and kind of spraying equipment appeared to not influence their pesticides perception. In this context, it becomes critical to consider the low technical and academic background of the extension agents from public services and the poor coverage of extension services. Associated with this is the little research done on pesticides and the poor link between research and extension. It is important in a community of farmers with low formal education because of calls the need for investments in both, formal and not formal education, and strengthening agricultural support institutions.

Table 5. Determinants of perception of pesticides.

Variables	Log. Coefficient	Std. Err.	ODDS
Gender (1 = Male, 2 = Female)	1,504 <sup>NS</sup>	1,123	4,500
Education	-0,878 <sup>a</sup>	0,387	0,416
Age (years)	0,383 <sup>NS</sup>	0,548	1,467
Purpose of production	0,326 <sup>NS</sup>	0,522	1,385



Use of pesticides (1 = Yes, 2 = No)	-0,943 <sup>NS</sup>	1,063	0,389
Training of pesticide applicators (1 = Yes, 2 = No)	2,813 <sup>b</sup>	0,865	16,667
Spraying equipment	-2,773 <sup>a</sup>	1,195	0,063

Significant at <sup>a</sup>1% and <sup>b</sup>5%; <sup>NS</sup> Not significant.

#### IV. CONCLUSION

Tomato growers in Chokwe Irrigation System are subject to high exposure to pesticides, which puts their health and the environment at risk. They do not have complete PPE or training in Pesticides administration technologies. Their perception of pesticides is limited and strongly related to the availability of training by government and non-government extension agents. Its necessary to capacity rural agents including extensionists and other rural actors in pesticides management skills, important in Integrated Pest Management. Its also important to create farmers associations to facilitate government and non-government interventions.

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