v. 4, n. 5, 2024

Journal of Engineering Research

USE AND MANAGEMENT OF PESTICIDES IN AGRICULTURAL AREAS OF THE STATE OF GUERRERO, MEXICO

Dr. Mireya Maruris Reducindo
Higher School of Natural Sciences
Universidad Autónoma de Guerrero
Chilpancingo, Guerrero, Mexico
https://orcid.org/0009-0000-5626-4644

Pedro Cortés Genchi
Faculty of Chemical-Biological Sciences
Universidad Autónoma de Guerrero
Chilpancingo, Guerrero, Mexico

Flaviano-Godínes Jaimes
Faculty of Mathematics - Universidad Autónoma de Guerrero
Chilpancingo, Guerrero, Mexico
https://orcid.org/0000-0001-5531-8989

Dr.Yanet Romero Ramírez
Faculty of Chemical-Biological Sciences
Universidad Autónoma de Guerrero
Chilpancingo, Guerrero, Mexico
https://orcid.org/0000-0002-8383-4128

Dr. Araceli Chino Cantor
Universidad Autónoma de Guerrero
Sustainable Production Engineering and Environmental Systems Engineering
Técpan de Galeana, Guerrero, Mexico
https://orcid.org/0009-0006-7925-4506

Dr. Sandra Quintana Ponce
Higher School of Natural Sciences.
``Universidad Autónoma de Guerrero``
Chilpancingo, Guerrero, Mexico
https://orcid.org/0000-0001-7184-994X

Abstract: Pesticides are used to control pests and diseases in agricultural fields, however, these agrochemicals can cause acute and chronic poisoning in farmers. An observational, cross-sectional study was carried out on farmers, with the objective of knowing the use and management of pesticides in four agricultural areas of the State of Guerrero: Huitziltepec, Chichihualco, Quechultenango and La Ceniza and estimating the prevalence of acute poisonings in this population. Materials and methods: a questionnaire of 35 questions related to the use and management of agrochemicals was applied to 407 farmers from the four areas. Results: Average age 46.0±16.29 years, 32.6% are illiterate, 89.6% did not use personal protective equipment. The highest prevalence of acute poisoning (61.64%) was recorded in the community of La Ceniza. The pesticides that caused acute poisoning were: paraquat, furadan, esteron counter, tamaron, faena and lannate. The most frequent symptoms reported by farmers were: headache, nausea/ vomiting, burning skin, blurred vision and dizziness. Conclusions: farmers used and handled agrochemicals inappropriately. It is recommended to train farmers in the proper use and management of agrochemicals, as well as in the use of alternative methods to control agricultural diseases and pests.
Keywords: pesticides, acute poisonings, use and management, exposed farmers.

INTRODUCTION

The use of pesticides has increased in the last 20 years in the agricultural field and in health campaigns for vector control (González-Valiente et al. 2001, Madeley 2002, Villaamil Lepori et al. 2013).

In Mexico, around 7 million people work in agriculture and it is estimated that 25.4% of its population may be directly exposed to pesticides (Valencia-Quintana et al 2023).

The use of these agrochemicals has harmful effects on health and environmental pollution (Hernández-Antonio and Hansen 2011, Villaamil Lepori et al. 2013, Bildfell et al. 2013). For example, glyphosate has been reported to have harmful effects on the nervous system, and an increased risk of autism spectrum disorders was also found in children when their mothers were exposed to glyphosate during pregnancy or in their first year of life (Sobjak et al 2017; Press Release, 2023).

Pesticides represent a serious health problem for exposed workers (Ortiz et al. 2013), because they cause acute and chronic poisoning. The risk of suffering from poisoning is greater when applicators do not use personal protective equipment during preparation and application (Montoro et al. 2009). In the 1980s, the World Health Organization (WHO, 1990) recorded one million serious cases of unintentional poisoning worldwide, of which 70% occurred due to occupational exposure; and the greatest number of acute poisonings is due to organophosphate pesticides, carbamates and bipyridyls (paraquat) (Cabrera and Varela 2009, Fernández et al. 2010).

In Mexico, from 1995 to 2012, 67,711 cases of pesticide poisoning were recorded throughout the country; The states that presented the highest rates at the end of the period are Colima 17.3, Nayarit 11.6, Morelos 8.7, Jalisco 8.4 and Guerrero 7.1. (SSA, 2013).

In the State of Mexico, 71.8% of poisonings occurred, the most frequent route of exposure was respiratory (48.5%), only 54.3% requested medical attention when the poisoning occurred (Hernández-González et al. 2007).

In the State of Guerrero, a prevalence of acute poisoning of 23% was reported in agricultural workers in the Tixtla Valley and the inadequate use and management of pesticides was observed (Cortés et al. 2008). The Ministry of Health of this state registered 254 cases of pesticide poisoning in 2013, until week 34, however there is an under-reporting of this problem (SSA, 2013).

According to the Ministry of the Environment and Natural Resources (SEMARNAT), in the state of Guerrero, a total of 1,329 acute pesticide poisonings have been registered from 2012 to 2019 (SSA, 2020); and in 2022, an incidence rate of pesticide poisoning of 5.73 per 100,000 inhabitants was recorded (SSA, 2023).

The objective of this research is to understand the use and management of pesticides in the agricultural areas of the communities of La Ceniza, Huitziltepec, Chichihualco and Quechultenango and to estimate the prevalence of acute poisoning in farmers exposed to pesticides.

METHODOLOGY

A cross-sectional study was carried out, in which 407 male farmers from four agricultural areas of the State of Guerrero, Mexico, participated. Sampling was non-probabilistic (for convenience) and was carried out from June to September. The sampled sites were: La Ceniza, Huitziltepec, Chichihualco and Quechultenango. Farmers who agreed to participate signed a letter of informed consent. A questionnaire was applied to them, which contains 35 questions related to the use and management of pesticides, hygiene habits, safety interval, symptoms caused by pesticides, work history, use of personal protective equipment, among others (Cortés et al., 2008). The inclusion criteria: farmers who applied pesticides in the last 12 months and the exclusion criteria: temporary applicators and farmers who had not applied pesticides in the last 12 months. Data capture was performed in Epi Data and statistical analysis in Stata.

DESCRIPTION OF THE STUDY AREA

The community of La Ceniza, Municipality of Marquelia is located in the Costa Chica Region of the State of Guerrero, 60 meters above sea level (masl), has a population of 385 inhabitants (INEGI, 2010). Chichihualco is located in the Central Region of the State of Guerrero, west of Chilpancingo, at 1140 meters above sea level, it has a population of 10,690 inhabitants. Huitziltepec, municipality of Eduardo Neri, is located in the Central Region of the State of Guerrero, at 1670 meters above sea level, and has a population of 4,305 inhabitants. Quechultenango is located southeast of Chilpancingo, capital of the State of Guerrero, at 860 meters above sea level and has 5,720 inhabitants (INEGI, 2012).

RESULTS

In the Community of La Ceniza, the main crops on which pesticides were applied were: corn (14%), chili (2%) and watermelon (2%). 82% used pesticides to control weeds. 89.6% of farmers do not use personal protective equipment (PPE). 5.8% (6/104) use a scarf to cover their mouth and 1.92% (2/104) use latex gloves. 37.5% (39/104) applied the pesticide from 10:00 a.m. to 4:00 p.m., being the hours of greatest risk due to the strong air currents in that area. The average pesticide application time was 4.93±2.10 SD, with a range of 1 to 9 hours. Farmers usually mix two or three pesticides in the same application. 80.95% of those who were poisoned did not go to the doctor due to lack of financial resources and because in some cases the poisoning was mild. Only four intoxicated people went to the doctor.

In the agricultural area of Chichihualco, corn, tomatoes, sorghum and beans are mainly grown. Generally in this area pesticides are applied in the morning, 75% of farmers apply them from 8:00 to 10:00. The average exposure time was 6.35±2.65 SD, with a range of 0.5 to 10 hours. In this area, farmers usually mix two pesticides in the same application.

In the agricultural area of Huitziltepec, farmers grow corn, tomatoes, beans, pumpkins and chili. 90% of farmers do not usually use personal protective equipment (PPE), despite this, they had the lowest prevalence of acute poisoning (Table 1). The average application time was 6.65±2.37 SD, with a range of 1 to 12 hours. Farmers mix up to four pesticides in a single application. Most farmers (91%) applied herbicides.

In the agricultural area of Quechultenango, the crops planted most frequently are: corn, beans, tomatoes, chili, cucumber, jicama and peanuts. The pests that occurred most frequently were: fall armyworm (*Spodoptera frugiperda*. J.E. Smith), white fly (*Bemisia tabaci*. Gennadius), gallina ciega (*Phyllophaga sp*) and different species of weeds. The average application time was 5.56±2.05 SD, with a range of 1 to 11 hours. Farmers often mix two or three pesticides in a single application. Tamaron, furadan and paraquat are the pesticides with which farmers in this town have been most poisoned.

The highest prevalence of acute pesticide poisoning (API) was recorded in the Community of La Ceniza. The pesticide that caused poisoning in the four sites studied was Paraquat, among others (Table 1.)

Of the four areas studied, the farmers from La Ceniza were the ones that reported the most symptoms and the farmers from Huitziltepec presented the least symptoms (Table 2).

In relation to the use and management of pesticides in the studied areas, the majority of applicators do not use personal protective equipment or only use some clothing; For the application of agrochemicals they use a backpack pump. It was also observed that most farmers do not respect the re-entry time to treated crops, as indicated in the instructions on the packaging. In the four agricultural

Agricultural area	Age Average	Age range (years)	Scholarship n (%)	PJI Prevalence	Pesticides that caused poisoning
The ashes (n=104)	40.92±16.43	16-80	The person reading=82 (78.8%) Illiterate=22 (21.2%)	61.54%	Furadan, esteron, paraquat, lannate, folimat, defensa, tordón, velcron 60, biofol, nudrin, coloso, foley, arrivo, pastar.
Chichihualco (n=103)	48.66±18.36	16-88	The person reading=71 (68.9%) Illiterate=32 (31.07%)	18.45%	Faena, furadan, tamaron, paraquat, counter, esteron, lannate, cypervel 200, disparo, karate.
Huitziltepec (n=100)	49.13±14.52	15-78	The person knows how to read = 50 (50%) Illiterate = 50 (50%)	8.0%	Faena, paraquat.
Quechultenango (n=100)	44.99± 15.87	16-80	The person knows how to read=72 (72%) Illiterate = 28 (28%)	21.0%	Faena, furadan, tamaron, paraquat, counter.

Table 1. Pesticides that caused poisoning in farmers in the four areas studied.

Symptoms	The ashes	Chichihualco	Huitziltepec	Quechultenango
Headache	X*	X	X	X
Nausea/vomiting	X	X		X
Fever	X			
Difficulty breathing	X			
Burning skin	X	X	X	X
Burning in eyes	X			
Excessive sweating	X			
Blurry vision	X	X		
Dizziness	X	X		X
Excessive thirst	X	X		
Body tremor		X		X

Table 2. Symptoms reported by farmers after applying the pesticide.

*Presence of symptoms

areas, those interviewed have knowledge of the danger of pesticides; However, they do not take the appropriate precautions for their proper use and management (Table 3).

Farmers used and handled pesticides inadequately, because they mixed pesticides, applied against the wind, and most did not use personal protective equipment, among other factors (Table 3).

In the crop fields of the four agricultural zones, after applying the pesticide, no danger signs were placed in the areas treated with agrochemicals. It was also observed that farmers discard empty containers of the pesticides used in the field.

DISCUSSION

Farmers from three agricultural areas (La Ceniza, Chichihualco and Quechultenango), 90 to 99% did not use personal protective equipment (PPE) when applying the pesticide, and therefore had the highest prevalence of acute poisoning 61.54%, 18.45% and 21.0% respectively; Other authors such as Evaristo et al (2022), in their research, report that 32.5% of farmers in the southern region of Brazil do not use PPE due to the excessive heat it causes and 21.5% reported having suffered pesticide poisoning. Zheng et al (2023) mention that the use of PPE by pesticide applicators significantly reduces exposure levels and health problems. On the other hand, Kafle et

Variables	The ashes	Chichihualco	Huitziltepec	Quechultenango
People mix pesticides				
Yes (%)	61.54	39.81	29.0	31.0
No (%)	38.46	60.19	71.0	69.0
Use of PPE				
Yes (only some items) (%)	7.7	1.0	10.0	23.0
No (%)	92.3	99.0	90.0	77.0
People apply pesticides				
Downwind (%)	28	56.31	69.0	58.0
Against (%)	12	23.30	31.0	7.0
Both forms (%)	60	20.39	__	35.0
Equipment used to apply the pesticide				
-Backpack bomb (%)	100	99.0	100.0	99.0
-With bare hands (%)	----	1.0	__	1.0
People read the label				
Yes (%)	21.0	42.72	27.0	35.0
No (%)	75.0	55.34	64.0	59.0
Sometimes (%)	4.0	1.94	9.0	6.0
Smoke during or after application				
Yes (%)	10.58	7.8	__	15.0
No (%)	89.42	92.2	100.0	85.0
Average time to bathe after applying pesticide (hours)	4.52±7.33	2.18±3.43	1.05±1.07	1.59±4.7
Average time to change clothes after application (hours)	5.87± 15.68	2.22±3.44	1.05±1.07	1.32±1.51
Average re-entry time to the crop (days)	2.85±3.10	3.48±5.04	5.68±5.42	4.57±4.86
Perception of farmers in relation to the risk of pesticide use				
They are dangerous (%)	100.0	81.0	83.0	94.0
They are not dangerous (%)	__	19.0	6.0	5.0
The person does not know (%)	__	___	11.0	1.0

Table 3. Indicators of pesticide use and management in farmers in four agricultural areas of the State of Guerrero, Mexico.

al (2021) points out that the low use of PPE is mainly due to farmers' lack of awareness, availability and high cost, and the discomfort they experience when using it due to the heat.

Of the areas studied, farmers in the community of La Ceniza had the highest prevalence of Acute Pesticide Intoxication (IAP), this is possibly due to the fact that 92.3% of these farmers do not use personal protective equipment and it is the community where A greater variety of pesticides are used (14 different pesticides), and the application is also carried out against the wind (12%); They do not respect the re-entry time to the crop since they return to the fumigated crop in three days on average, and 62% of farmers mix or combine pesticides when applying them; Therefore, the toxicity of the product increases. Another factor that can contribute to the high prevalence of acute poisoning in this agricultural area is the warm climate, which can favor exposure through the dermal route and cause PJI. Guzmán-Plazola et al (2016) mention that the risk of suffering acute poisoning from pesticides is related to the absence of technical knowledge, lack of training in the management and use of agrochemicals, and little information from commercial companies. Other authors, such as Evaristo et al (2022), mention that people exposed to pesticides cause changes in their bodies and make them more vulnerable to health problems.

In our study, the pesticides that caused acute poisoning and that were used most frequently were: paraquat, furadan, esteron, counter, tamaron, faena and lannate. Other authors such as Guzmán-Plazola et al (2016)

report in their study Lannate, faena, furadan and tamaron as the most frequent.

The farmers of Huitziltepec presented only two symptoms and 8% of acute poisoning, this prevalence was lower compared to the prevalence of the other three areas studied, this is perhaps due to the fact that the farmers of Huitziltepec used fewer pesticides and the average re-entry time to the cultivation was 6 days and in the other areas it was fewer days.

The majority of farmers (55-75%) in the areas studied do not read the label before applying the pesticide; Therefore, they are unaware of the correct handling of the product and the warnings specified by the manufacturer. As mentioned by Damalas et al (2016), agrochemical producers label the product in which they specify the handling and toxicity of the pesticide. Therefore, it is of utmost importance to read the contents of the label to make good use of the product.

Due to the poverty in which farmers in the State of Guerrero, Mexico, are found and the high exposure to pesticides due to improper use and management, it is necessary for health authorities to supervise agricultural areas and provide medical care to the population of farmers, and at the same time guide them for the proper use and management of pesticides, since they are toxic substances that cause diseases to those who are exposed to these agrochemicals. García-Pineda and Bravo-Vallejos (2022) mention that a low socioeconomic level leads to a low capacity to invest in prevention and that it could be an important cause that contributes to the risk of occupational and paraoccupational exposure due to the use of pesticides.

Valencia-Quintana, et al (2023) recommends promoting the use of protective measures, as well as compliance with labor regulations, for the prevention of risks in agricultural workers, which minimize the risks of exposure to pesticides. However, the best solution is to reduce the use of these pesticides as much as possible and practice organic agriculture, with the support of the federal government, who would allocate a special budget for those farmers who produce safe food, free of pesticide residues.

CONCLUSIONS

Farmers in the four agricultural zones used and handled pesticides inadequately, because the majority do not use personal protective equipment when preparing and applying agrochemicals, therefore, they are at greater risk of suffering from poisoning.

The highest prevalence of acute poisoning occurred in workers in the agricultural area of La Ceniza with 61.54%, and the lowest prevalence occurred in farmers in Huitziltepec (8%).

The pesticides that caused acute poisoning, and that were used most frequently, were: paraquat, furadan, esteron, counter, tamaron, faena and lannate.

RECOMMENDATIONS

It is recommended to train farmers for the proper use and management of agrochemicals, as well as the use of alternative methods for the control of agricultural pests, such as Integrated Pest Management (IPM), with the purpose of reducing the harmful effects on the crop. health of the applicator, protect the environment and achieve more sustainable organic agriculture.

REFERENCES

Bildfell, J.R., K.W Rumbeiha., L.K. Schuler., U.C. Meteyer., L.P. Wolff., M.C. Guillin. (2013). **A review of episodes of zinc phosphide toxicosis in wild geese (Branta spp.) In Oregon (2004-2011)**, *J VET Diagn Invest*, 25 (1).

Cabrera, O.A y R.W. Varela. (2009). **Intoxicación por organofosforados (Revisión del diagnóstico y manejo)**, *Revista Médica de Costa Rica y Centroamérica*, Vol. LXVI, No.588.

Cortés-Genchi, P., A.A.Villegas., G. Aguilar-Madrid., MP. Paz-Román., M. Maruris-Reducindo., C.A. Juárez-Pérez. (2008). **Síntomas ocasionados por plaguicidas en trabajadores agrícolas**, *Rev Med Inst Mex Seguro Soc*, 46 (2).

Damalas, CH.A & Koutroubas, S.D. (2016). **Farmers' Exposure to Pesticides: Toxicity Types and Ways of Prevention**, *Toxics*, 4(1). doi:10.3390/toxics4010001

Evaristo A, Pedroso DO, Rech NLS, Bombardi LM, Silva BF, Siegloch AE & Agostinetto L. (2022). **Pesticides and farmers' health: an analysis of variables related to management and property,** An Acad Bras Cienc 94: e20211335. DOI 10.1590/0001-3765202220211335.

Fernández A, D. G., Mancipe G. L. C., & Fernández A. D. C. (2010). **Intoxicación por organofosforados**. *Revista Med*, 18(1),84-92.[fecha de Consulta 26 de Diciembre de 2023]. ISSN: 0121-5256. Recuperado de: https://www.redalyc.org/articulo.oa?id=91019823013

Garcia-Pineda L, Bravo-Vallejos N. (2022). **Conocimientos, actitudes y prácticas sobre el uso de plaguicidas por agricultores en una zona rural de Copán Ruinas, Honduras, año 2019.** *MÉD.UIS*, 35(2):49-57. DOI: https://doi.org/10.18273/revmed.v35n2- 2022005

González-Valiente, M.L., Capote-Marrero, B., Rodríguez-Duran E. (2001). **Mortalidad por intoxicaciones agudas causadas por plaguicidas**, *Rev Cubana Hig Epidemiol*, 39 (2).

Guzmán-Plazola, P., Guevara-Gutiérrez, RD., Olguín-López, JL., Mancilla-Villa, OR. (2016). **Perspectiva campesina, intoxicaciones por plaguicidas y uso de agroquímicos.** *IDESIA (Chile)*, 34 (3). Consultado 20/12/2023 https://www.scielo.cl/pdf/idesia/v34n3/art09.pdf

Hernández-Antonio, A., Hansen, A.M. (2011). **Uso de plaguicidas en dos zonas agrícolas de México y evaluación de la contaminación de aguas y sedimentos**, *Rev Int Ambie*, 27 (2).

Hernández-González, M.M., C. Jiménez-Garcés., F.R. Jiménez-Albarrán y M.E. Arceo-Guzmán. (2007). **Caracterización de las intoxicaciones agudas por plaguicidas: perfil ocupacional y conductas de uso de agroquímicos en una zona agrícola del estado de México, México**, *Rev Int Contam Ambient,* 23 (4).

INEGI. Instituto Nacional de Estadística y Geografía. (2010) **Censo de población y vivienda**.

INEGI. (2012). **Estadística del Medio Ambiente**. Instituto Nacional de Estadística, Geografía e Informática, México. Mapa satelital de Quechultenango, Guerrero.

Kafle, S., Vaidya, A., Pradhan, B., Jørs, E., Onta, S. (2021). **Factors Associated with Practice of Chemical Pesticide Use and Acute Poisoning Experienced by Farmers in Chitwan District, Nepal.** Int. J. Environ. Res. Public Health, 18, 4194. https://doi.org/10.3390/ijerph18084194

Madeley, J. (2002). **Paraquat el controvertido herbicida de Syngenta. Informe para Berne Declaration.** Foro Emaús. www.evb.ch 8.

Montoro, Y., R. Moreno., L. Gomero y M. Reyes. (2009). **Características de uso de plaguicidas químicos y riesgos para la salud en agricultores de la Sierra Central del Perú**, *Rev Peru Med Exp Salud Publica,* 26 (4).

Ortiz, I., MA. Ávila-Chávez y G.L. Torres. (2013). **Plaguicidas en México: usos, riesgos y marco regulatorio**, *Revista Latinoamericana de Biotecnología Ambiental y Algal*, 4 (1).

Press Release (Sept 27 PAN Europa). (2023). **Criminal Complaint Against Bayer for Concealing Glyphosate Risks to Pregnant Women**. Consultado 12/12/2023. https://www.pan-europe.info/sites/pan-europe.info/files/public/resources/press-releases/Criminal%20Complaint%20Against%20Bayer%20for%20Concealing%20Glyphosate%20Risks%20to%20Pregnant%20Women.pdf.

Sobjak, TM., Romao, S., Zwetzch do Nascimento, C., Potulski dos Santos, AF., Vogel, L., Bittencourt Guimaraes, AT. (2017). **Assessment of the oxidative and neurotoxic effects of glyphosate pesticide on the larvae of Rhamdia quelen fish**. *Chemosphere* (182), 267-275 pp. http://dx.doi.org/10.1016/j.chemosphere.2017.05.031

Secretaria de Salud [SSA] (2013). **Panorama histórico de morbilidad y mortalidad por intoxicación por plaguicidas en México 1995-2012**, *Boletín Epidemiológico,* 30 (35), Semana 35. Secretaria de Salud, (en línea) http://www.epidemiologia.salud.gob.mx/doctos/boletin/2013/completo/sem35.pdf.

Secretaría de Salud [SSA] (2020). **Anuario de Morbilidad 1984 - 2019**, consultado en http://www.epidemiologia.salud.gob.mx/anuario/html/anuarios.html, 03-09-2020.

Secretaria de Salud [SSA]. Dirección General de Epidemiología.(05 de julio de 2023). **Anuarios de Morbilidad 1984 a 2022.** Consultado en https://www.gob.mx/salud/acciones-y-programas/anuarios-de-morbilidad-1984-a-2022

Valencia-Quintana, R., Mili C., Bonassi, S., Ochoa-Ocaña, M.A., Campos-Peña, V., Tenorio-Arvide, M.G., Pérez-Flores, G.A., Sánchez-Alarcón, J. (2023). **Effect of Pesticide Exposure over DNA Damage in Farmers from Los Reyes, Michoacan en Mexico.** *Tóxicos*, 11, 122. https://doi.org/10.3390/toxics11020122

Villaamil- Lepori, E.C., G. Bovi- Mitre y M. Nassetta. (2013). **Situación actual de la contaminación por plaguicidas en Argentina**, *Rev Int Contam Ambie*, 29.

WHO. (1990) **Public Health impact of Pesticides Used in Agriculture**, **Genéve**: World Health Organization, 1990.

Zheng, R., García-González, J., Romero-del Rey, R., López-Villén, A., García-Alvarez, R., Fadul-Calderon, R., Requena-Mullor, M., Alarcón-Rodríguez, R. (2023). **Occupational Exposure to Pesticides as a Risk Factor for Sleep Disorders**. Int. J. Environ. Res. Public Health, 20, 3149. https://doi.org/ 10.3390/ijerph20043149