RESEARCH ARTICLE

Sokoto Journal of Veterinary Sciences

(P-ISSN 1595-093X: E-ISSN 2315-6201)

http://dx.doi.org/10.4314/sokjvs.v18i3.2

Oridupa *et al*. /*Sokoto Journal of Veterinary Sciences*, **18**(3): 129 - 136.

Knowledge, attitude and perception of related toxicity of pesticide exposure in humans and animals in Ibadan, Nigeria

OA Oridupa[1]*, KO Awotunsin[1], J Ogunsola[2], AB Saba[1] & AD Obisesan[1]

[1.] *Department of Veterinary Pharmacology and Toxicology, University of Ibadan, Nigeria*
[2.] *Veterinary Teaching Hospital, University of Ibadan, Nigeria*

*Correspondence: Tel.: +2348056666304; E-mail: olayinkaolumide2000@yahoo.com

Publication History:
Received: 27-04-2020
Accepted: 01-07-2020

Abstract

This study reported knowledge, attitude and perception of pesticide use among farmers to determine the level of farmers' education on use and handling of pesticides. Data on pesticide types purchased were collected from pet-shops and agro-allied stores in three states in Nigeria. Questionnaires were administered to 100 farmers within Ibadan (Oyo State) to determine specific pesticides used, handling procedures adopted by farmers, protective measures employed and perception of toxic potentials of pesticides to human handlers and exposed animal. Survey reports showed majority used DDVP, 34% of farmers were uneducated, while 42%, 18% and 6% had primary, secondary and tertiary education, respectively. About 63.5% had been farming for 11-20years, 75% kept poultry while others kept sheep/goat and cattle. About 75% sought information from extension agents on pesticide use. The farmers were aware pesticides pose health hazards to animals but only 75% knew it could affect humans, 40% knew of pesticide withdrawal period with diverse opinions on route of pesticide poisoning. The study concluded that farmers and pet-owners in Southwest Nigeria use pesticides unethically and majority are unaware of toxicity and hazards of misuse and handling of pesticides, consequently exposing themselves and animals to hazardous and toxic pesticide levels. Legislations on pesticides enacted to prevent pesticide abuse should be enforced and awareness campaigns intensified to enlighten farmers and pet-owners on potential hazard pesticides pose to themselves, animals and environment. This would eventually prevent unnecessary exposure through misuse/mishandling of pesticides and create a safer ecosystem at large.

Keywords: Attitude, Knowledge, Perception, Pesticide, Toxicity

Introduction

A pesticide is any substance or mixture of substances intended for preventing; destroying, repelling, mitigating or controlling any pest, including vectors of human or animal diseases (Garcia *et al.*, 2012; Rizzati *et al.*, 2016). Pesticides include species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs. Also, pesticides are substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies (Ghuman *et al.*, 2003; de Camargo *et al.*, 2018).

Pesticides are classified according to their target organism (e.g. herbicides, rodenticides, insecticides), chemical structure (e.g. synthetic, organic, inorganic) and physical state (e.g. gaseous) [WHO, 2011]. A major class of pesticides is the organophosphates which are neurotoxic by inhibiting acetylcholinesterase (AchE), the enzyme which destroys acetylcholine at cholinergic receptors (Sorgob & Vilanova, 2002). Organophosphate insecticides form a transient intermediate complex with the active site on the AchE protein, resulting in partial hydrolyses of the site, leaving a stable phosphorylated and largely non- reactive inhibited enzyme with very low reactivation rate (Ecobichon, 1996).

Dichlorvos [2,2 Dichlorovinyl dimethyl phosphate (DDVP)] is an insecticide of the organophosphate (OP) group which has been in use since about 1955 in major parts of the developing world and in some parts of the developed world (Dang *et al.*, 2017). Dichlorvos is an insecticide which acts following oral, respiratory or dermal exposure. Like many organophosphate insecticides, it inhibits the enzyme cholinesterase, which results in disruption of the nervous and muscular system (Duncan *et al.*, 2020). DDVP is classified by the WHO as a Class IB, highly hazardous chemical (WHO, 2020). The dermal toxicity is similar to oral toxicity, and dermal exposure is a cause for concern for human handlers and in-contact animals (McCauley *et al.*, 2006). In addition to the neurotoxicity and gastrointestinal toxicity (Ascherio *et al.*, 2006; Beseler *et al.*, 2008; Baldi *et al.*, 2010; Yang *et al.*, 2011), DDVP increases oxidative stress (Altuntas & Delibas, 2002; Abdollahi *et al.*, 2004; Fortunato *et al.*, 2006), poses reproductive, haematological and hepatic hazards (Bustos-Obregon & Gonzales-Hormazabal, 2003; Celik *et al.*, 2009), maybe genotoxic and carcinogenic (Ismael *et al.*, 2006; Bassil *et al.*, 2007; Jurewic & Hanke, 2008; Van Maele-Fabry *et al.*, 2010).

This study sought to determine the most frequently requested and purchased pesticides from pet shops and agro-allied stores in three commercial cities of three states in Southwest Nigeria (Oyo, Ogun and Lagos States). Furthermore, a survey was carried out with 100 farmers responding. The knowledge of these farmers who primarily handle these pesticides, their attitude to good agricultural practices and their overall perception of the toxic potentials of pesticides were determined in the survey.

Materials and Methods

Sales data were collected from pet shops and Agro-allied stores in Lagos, Abeokuta and Ibadan Metropolis about different pesticides commercially available. This survey showed that Dichlorvos, Cypermethrin, Pyrethroids and Cyalothrins are the leading pesticides purchased by farmers. Based on this information, questionnaires were designed and circulated among farmers within Ibadan.

The questions asked included socio-demographic characteristics of the respondents; age, sex, religion, marital status, level of education. How long they had been in business, types of animals raised and size of the farm. Other questions included their sources of information on pesticide use and specific types of pesticides used. The questionnaires assessed the knowledge of the farmers on pesticide use with the implications of the potential hazards these chemicals may pose to in-contact humans and animals. The attitude of the farmers to use of banned pesticides, personal protective equipment, storage of these pesticides in living quarters, disposal of used pesticide containers, re-purposing of such for domestic uses and the difference between outdoor and domestic pesticides were assessed.

Furthermore, the farmers' perception of compliance with manufacturer's specification for the reconstitution of these pesticides and observation of withdrawal periods were assessed. The questionnaire also asked how accidental or purposive pesticide poisoning in humans and animals were handled, and farmers' awareness of legislations guiding the use of pesticides in Nigeria.

Results

Socio-demographic characteristics of the respondents

Overall, one hundred farmers in Ibadan metropolis were selected for this study, with mean age of 44.8±12.3 years. The age of 35% of the respondents was ≤40 years. Majority of the respondents (80.0%) were males, married (90.0%) and practiced Islamic religion (75.0%). Thirty four percent had no education, while 42.0%, 18% and 6% had primary, secondary and tertiary education respectively. Sixty-three percent had been in the business of rearing animals for between 11-20 years. About three-quarter kept poultry while 10.0% and 15.0% reared sheep/goat and cattle respectively. More than 40% of the farmers had more than a thousand livestock animals on their farms. About three-quarter of the farmers sought information from extension agents on the use of pesticides (Table 1). The major pesticides used by all the farmers were Dichlorvos (66.7%) and Cypermethrin (16.7%) (Figure 1).

Table 1: Socio-demographic characteristics of the respondents to the Knowledge, Attitude and Perception of farmers to pesticides use survey in Ibadan, Nigeria

Variable	Frequency
Age (years)	
≤40	35
41-45	10
46-49	15
>49	40
Sex	
Male	84
Female	16
Religion	
Christianity	25
Islam	75
Marital Status	
Single	10
Married	90
Highest Educational Level	
None	34
Primary	42
Secondary	18
Tertiary	6
For how long have you been in business? (years)	
11-20	63
21-30	12
>30	25
What type of animals do you keep?	
Poultry	75
Sheep and goat	10
Cattle	15
What is the size of your farm?	
<100 animals	12
100 – 500 animals	18
500 – 1000 animals	28
1000 – 5000 animals	32
>5000 animals	10
Do you have contacts with extension agents on the use of pesticides?	
Yes	75
No	25

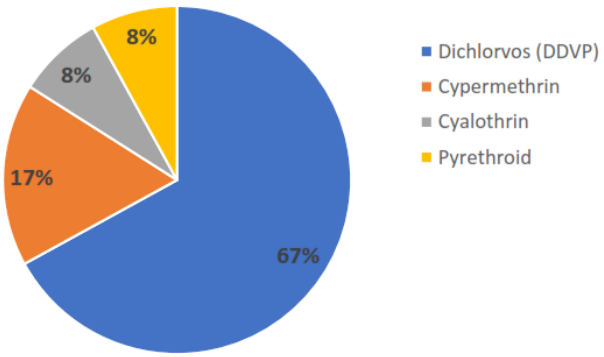

Figure 1: Pie chart showing percentages of the choice of pesticides by farmers in Ibadan, Nigeria

Knowledge of pesticide use

The respondents displayed a good knowledge of pesticide use. They had a mean score of 6.25 from a total of 11 which was greater than the average rating scale (5.5). Also, 84.0% of the respondents had a score which was greater than the average rating scale (Table 2). Moreover, all the farmers knew that pesticides can pose health hazards to their animals while only three-quarter knew that pesticides could also affect humans. All the farmers knew of pesticide poisoning or toxicity. The major means listed by the farmers through which animal/human could be poisoned in included ingestion (52.6%), contact (29.0%) and inhalation

Table 2: Summary indices for knowledge, attitude and perception of pesticide use adopted by farmers in Ibadan, Nigeria

Variable	Minimum score attainable	Maximum score attainable	Mean ± SD	Average scale	Categories	Frequency (%)
Knowledge	0	11	6.25 ± 1.81	5.5	Good	84 (84.0)
					Poor	16 (16.0)
Attitude	0	7	2.92 ± 0.65	3.5	Good	37 (37.0)
					Poor	63 (63.0)
Perception	0	24	9.75 ± 1.22	12.0	Good	29 (29.0)
					Poor	71 (71.0)

(18.4%). Less than 40% knew of pesticide withdrawal period. Major signs/symptoms of pesticide poisoning seen in animals/man were nausea/vomiting/diarrhoea (73.0%), nervous signs (8.8%) and skin reactions (18.3%). About 60% of the respondents had suffered from at least one of these signs/symptoms in the past (Table 2 and 3).

Table 3: Knowledge of pesticide use by farmers in Ibadan, Nigeria

Variable	Frequency
Do you know pesticides can pose health hazards to your animals?	
Yes	100
Do you know that the use of pesticides can pose health hazards to humans?	
Yes	75
No	25
Do you know of pesticide poisoning or toxicity?	
Yes	100
By what means do you know an animal/human could be poisoned by pesticide?	
Inhalation	35
Ingestion	100
Contact	55
Do you know of withdrawal period of pesticide?	
Yes	37
No	63
What signs of pesticide poisoning have you seen in animals/man?	
Nausea/Vomiting/Diarrhoea	100
Nervous signs	12
Skin reactions	25
Have you suffered from any of these signs/symptoms before?	
Yes	58
No	25
Don't Know	17

Attitude to pesticide use

The respondents displayed a poor attitude towards pesticide use. They had a mean score of 2.92 from a total of 7. The mean score was lower than the average rating scale (3.5) and also 63.0% of the respondents had a score which was lower than the average rating scale (Table 2 and 4). All the respondents believed that use of banned agricultural pesticides, storage of pesticides in family bedroom and use of outdoor pesticides for household pests is hazardous to health. Eighty-one percent reiterated that use of leaking equipment for pesticide administration and 73.0% acknowledge that improper disposal of pesticide containers is dangerous to environmental health. Sixty-two percent believed that failure to wear protective clothes/equipment is not hazardous to health while a similar proportion agreed that using pesticide containers for domestic purposes is hazardous to health (Table 4)

Perceptions of pesticide use

The respondents displayed a poor perception of pesticide use. They had a mean score of 9.75 from a total of 24.0 (Table 5). The mean score was lower than the average rating scale (12.0) and also 71.0% of the respondents had a score which was lower than the average rating scale (Table 2).

Only three-quarters of the respondents sometimes read pesticide labels before use, only 33.0% always mix pesticides in use, 19.0% had never used protective clothing while spraying and 64.0% never observed withholding period of at least 6 – 12 hours after spraying. After pesticide use, more than 30% of the respondents burn the containers or dispose of them on the field others dispose of them by burial

(15.9%) of recycling for domestic use (22.0%) (Table 5). In the case of suspected pesticide poisoning in animals, 49.8% of the farmers will call a veterinarian, 31.3% will slaughter the animal, 13.9% will treat the animal themselves, while 5.0% will leave the animal to either die or recover. For suspected pesticide poisoning in humans, 89.3% of the farmers will take the victim to the hospital, while others will treat him or her at home with local drugs. More than 95% were not aware of any legislation(s) guiding the use of pesticides in Nigeria and 72.0% do not think that pesticide use is being abused in Nigeria (Table 5).

Table 4: Attitude of farmers in Ibadan, Nigeria to pesticide use

Variable	Frequency
Use of banned agricultural pesticides is Hazardous to health	
Yes	100
Failure to wear protective clothes/equipment is hazardous to health	
Yes	38
No	62
Storage of pesticides in family bedroom is hazardous to health	
Yes	100
Improper disposal of pesticide containers is dangerous to environmental health	
Yes	73
No	27
Using pesticide containers for domestic purposes is hazardous to health	
Yes	61
No	39
Use of outdoor pesticides for household pests is hazardous to health	
Yes	100
Use of leaking equipment for pesticide administration is hazardous to health	
Yes	81
No	19

Table 5: Perception of pesticide use adopted by farmers in Ibadan, Nigeria

Variable	Frequency
How often do you read pesticide labels before use?	
Always	25
Sometimes	75
Never	0
How often do you mix pesticides in use?	
Always	33
Sometimes	67
Never	0
Do you wear protective clothing while spraying?	
Always	18
Sometimes	63
Never	19
Do you observe waiting period of at least 6 – 12 hours after spraying?	
Always	7
Sometimes	29
Never	64
How do you dispose of the pesticide containers after use?	
On the field	97
Burial	49
Burning	95
Recycled for domestic use	68
What do you do in case of suspected pesticide poisoning in animals?	
Call a vet	100
Treat the animal themselves	28
Leave the animal to either die or recover	10
Slaughter the animal	63
What do you do in case of suspected pesticide poisoning in humans?	
Take the victim to the hospital	100
Treat him or her at home with local drug	12
Are you aware of any legistlation(s) guiding the use of pesticides in Nigeria?	
Yes	4
No	96
Do you think that the use of pesticides in Nigeria is being abused?	
Yes	28
No	72

Discussion

Pesticides are chemicals developed to eliminate organisms such as insects which are harmful or destructive to cultivated plants or animals (Garcia *et al.*, 2012). Its use must however be regulated with manufacturer's recommendations adhered to for the safety of in-contact humans and animals (WHO, 2011). This study determined the most frequently used pesticides in Southwest Nigeria and assessed the knowledge, attitude and perception of pesticide use among farmers. Results gathered from the study showed that legislations guiding the use of pesticides in Nigeria are not being

enforced and also, little awareness is being created concerning proper use of pesticides. Laws have been enacted and enforced in developing countries to prevent accidental, work-related or malicious exposure to pesticides (EU, 2012; EU, 2013). Pesticide misuse is on the increase in Nigeria and an average pesticide user/handler suffers the consequences of the abuse as well as the contact animals and the environment (Jalali *et al.*, 2003; Fox *et al.*, 2007; Arias-Estévez *et al.*, 2008; Decourtye & Devillers, 2010; Yasmin & D'Souza, 2010). Respondents to the survey were young married males in their active work years (30-60 years). A minority had tertiary education (6%) while about one third had no formal education. Majority were poultry farmers (75%) that had been in the business for 11-20 years (63%). The results show that most of these farmers had a good knowledge of pesticide use (84%), but very poor attitude and perception of pesticide use. This may be explained by their low level of application of knowledge which may have been acquired from their extension service workers. It is noteworthy at this point to mention that the most commonly used and invariably abused pesticide by these farmers is Dichlorvos (DDVP), an organochlorine pesticide that became popular after the ban of previously synthesized organochlorines such as sarin, soman, tabun, chlorpyrifos, ethion (Aluigi *et al.*, 2005).

It would be a fallacy to think individuals are unaware of the hazards posed by pesticides (MacFarlane *et al.*, 2013). This was confirmed by the response from all these farmers. However, most of the respondents knew of oral route of exposure and a considerable majority was unaware of other routes of exposure such as skin and respiratory tract. Thredgold *et al.* (2019) re-emphasized the important role of dermal exposure in pesticide-induced toxicity in farm workers with almost 500-fold increased cumulative permeability of DDVP under elevated farm environmental temperature. Exposure to sunlight induces photodegradation of organophosphates including DDVP which generates reactive oxygen species. These by-products of photo-reactivity are more toxic than the parent toxicant, DDVP (Bustos *et al.*, 2019). Exposure via the respiratory route cause no less toxicity as DDVP is highly volatile and lipophilic at very low concentrations (Aulicky *et al.*, 2019).

The most common symptoms of poisoning observed by the farmers had been gastrointestinal symptoms of nausea, vomition and diarrhea, which most of them had suffered from at some point in time. Despite personal experiences of poisoning, most of them did not use personal protective equipment or believe failure to wear protective clothes/equipment was hazardous to health. The role of personal protective equipment has been emphasized and proven by previous researchers as a means of preventing occupational exposure to pesticides (MacFarlane *et al.*, 2013; Thredgold *et al.*, 2019). Also, a vast majority was unaware of withdrawal periods and as such was not observing them. In essence, the farmers had a poor attitude to pesticide use and this was reflected in their perceptions as well. Farmers did not habitually read manufacturers' instructions, regulate in-use conditions, or protect the environment from residues of the pesticides after use and most pesticide containers were recycled for domestic use. DDVP has mutagenic, carcinogenic, endocrine disruption potential in various organisms including man making unguarded exposure a great hazard (de Camargo *et al.*, 2018; Pereira *et al.*, 2019). In the case of suspected pesticide poisoning in animals, all the farmers will call a veterinarian, but a majority will slaughter such an animal and carcass may be dressed for human or other animal consumption. Poisoning cases in humans were taken to the hospital for proper medical care in most cases. In totality, most of these farmers (96%) are unaware of legislations regulating handling and use of pesticides in Nigeria. The general misconception is that their current adopted methods are safe for in-contact humans, animals and the environment.

In conclusion, the results showed that majority of the farmers (72%) did not believe pesticides are being abused in Nigeria especially DDVP, and thus were unaware of the consequences of abuse. This calls for heightened awareness campaigns on the known and yet to be known deleterious effects of these pesticides and their residues in food for human and animal consumption. Farmers needed to be educated on the current and latent hazards been unleashed by unregulated exposure of the environment and the ecosystem as a whole.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abdollahi M, Ranjbar A, Shadnia S, Nikfar S & Rezale A (2004). Pesticides and oxidative stress: a review. *Medical Science Monitor,* **10**(6): RA141-147.

Altuntas I & Delibas N (2002). Effects of organophosphate imedicidefenthion on lipid peroxidation and antioxidant enzymes in rat erythrocytes: the role of vitamins E and C. *Biomedical Research,* doi.10.1191/0960327102ht304oa.

Aluigi MG, Angelini C, Falugi C, Fossa R, Genever P, Gallus L, Layer PG, Prestipino G, Rakonczay Z, Sgro M, Thielecke H & Trombino S (2005). Interaction between organophosphate

compounds and cholinergic functions during development. *Chemico-Biological Interaction,* doi.10.1016/j.cbi.2005.10.037.

Arias-Estévez, M, López-Periago E, Martínez-Carballo E, Simal-Gándara J, Mejuto JC & García-Río L (2008). The mobility and degradation of pesticides in soils and the pollution of groundwater resources. *Agriculture, Ecosystems & Environment*, **123**(4): 247–260.

Ascherio A, Chen H, Weisskopf MG, O'Reilly E, McCullough ML, Calle EE, Schwarzschild MA & Thun MJ (2006). Pesticide exposure and risk for Parkinson's disease. *Annals of Neurology,* **60**(2): 197–203.

Aulicky R, Stejskal V & Opit G (2019). Short-exposure biological activity of dichlorvos insecticide strips on coleopteran storage pests under two evaporation regimes: Can slow-release dichlorvos formulations replace aerosols? *Pakistan Journal of Zoology,* **51** (2): 475-482.

Baldi I, Gruber A, Rondeau V, Lebailly P, Brochard P & Fabrigoule C (2010). Neurobehavioral effects of long-term exposure to pesticides: results from the 4-year follow-up of the PHYTONER Study. *Occupational and Environmental Medicine,* **68** (2): 108–115.

Bassil KL, Vakil C, Sanborn M, Cole DC, Kaur JS & Kerr KJ (2007). Cancer health effects of pesticides: systematic review. *Canadian Family Physician,* **53** (10): 1704–1711.

Beseler CL, Stallones L, Hoppin JA, Alavanja MCR, Blair A, Keefe T & Kamel F (2008). Depression and pesticide exposures among private pesticide applicators enrolled in the Agricultural Health Study. *Environmental Health Perspective*, **116** (12): 1713–1719.

Bustos N, Cruz-Alcalde A, Iriel A, Cirelli AF & Sans C (2019). Sunlight and UVC-254 irradiation induced photodegradation of organophosphorus pesticide dichlorvos in aqueous matrices. *Science of the Total Environment,* doi.10.1016/j.scitotenv.2018.08.254.

Bustos-Obregon E & Gonzales-Hormazabal P (2003). Effect of a single dose of malathion on spermatogenesis in mice. *Asian Journal of Andrology,* **5**(2): 105-107.

Celik I, Yilmaz Z & Turkoglu V (2009). Hematotoxic and hepatotoxic effects of dichlorvos at sublethal dosages in rats. *Environmental Toxicology,* **24**(2): 128-132.

de Camargo MR, Akamine PVT, Venturini J, de Arruda MSP & da Silva Franchi CA (2018). Pesticide dichorvos induces early solid Ehrlich tumoral development associated with a non-protective pro-inflammatory response. *Environmental Science Pollution Research,* **25**(8): 7681–7687.

Dang K, Doggett SL, Singham VG & Lee CY (2017). Insecticide resistance and resistance mechanisms in bed bugs, Cimex spp. (Hemiptera: Cimicidae). *Parasites Vectors,* doi.10.1186/s13071-017-2232-3.

Decourtye A & Devillers J (2010). Ecotoxicity of neonicotinoid insecticides to bees. *Advances in Experimental Medicine and Biology,* doi.10.1007/978-1-4419-6445-8_8.

Duncan WP, Idalino JJS, da Silva AG, Moda RF, da Silva HCM, Matoso DA & Gomes ALS (2020). Acute toxicity of the pesticide trichlorfon and inhibition of acetylcholinesterase in *Colossoma macropomum* (Characiformes: Serrasalmidae). *Aquaculture International* **28**(2): 815–830.

Ecobichon DJ (1996). Toxic effects of pesticides. In: Casarett and Doull's Toxicology: The Basic Science of Poisons (CD Klaassen, J Doull J, editors). Fofth edition. New York: MacMillan. Pp 643–689.

EU (2012). Commission decision concerning the non-inclusion of dichlorvos for product type 18 in Annex 1, 1A or 1B to directive 98/8/EC of the European parliament and of the council concerning of biocidal products on market. Official Journal of the European Union. 2012/254/EU.

EU (2013). Amending Annex 1 and V to regulation (EC) No 689/2008 of the European parliament and of the council concerning the export and import of dangerous chemicals. Official Journal of European Union, Commission regulation No 78/2013.

Fortunato JJ, Feier G, Vital AM, Petronilho FC, Dal-Pizzol F & Quevedo J (2006). Malathion-induced oxidative stress in rat brain regions. *Neurochemical Research,* **31**(5): 671-678.

Fox JE, Gulledge J, Engelhaupt E, Burrow ME & McLachlan JA (2007). Pesticides reduce symbiotic efficiency of nitrogen-fixing rhizobia and host plants. *Proceeding of the National Academy of Science USA,* **104** (24): 10282–10287.

Garcia FP, Ascencio SYC, Oyarzun JCG, Hernandez AC & Alavarado PA (2012). Pesticides: classification, uses and toxicity. Measures of exposure and genotoxic risks. *Journal of Research in Environmental Science and Toxicology,* **1**(11): 279-293.

Ghuman SPS, Ratnakaran U, Bedi JS & Gil JPS (2003). Impact of pesticide residues on fertility of

dairy animals: A review. *Indian Journal of Animal Science,* **83**(12): 1243–1255.

Ishmael J, MacGregor JA & Manley A (2006). Dichlorvos - a comprehensive review of 11 rodent carcinogenicity studies. *Regulatory Toxicology and Pharmacology,* **44** (3): 238-248.

Jalali N, Pajoumand A, Abdollahi M & Shadnia S (2003). Epidemiological survey of poisoning mortality in Tehran during 1997-1998. *Toxicology Letter,* **1**: 309.

Jurewicz J & Hanke W (2008). Prenatal and childhood exposure to pesticides and neurobehavioral development: review of epidemiological studies. *International Journal of Occupational Medicine and Environmental Health,* **21**(2): 121–132.

MacFarlane E, Carey R, Keegel T, El-Zaemay S & Fritschi L (2013). Dermal exposure associated with occupational end use of pesticides and the role of protective measures. *Safety and Health at Work,* **4**(3): 136–141.

McCauley LA, Anger WK, Keifer M, Langley R, Robson MG & Rohlman D (2006). Studying health outcomes in farmworker populations exposed to pesticides. *Environmental Health Perspectives,* **114**(3): 953–960.

Pereira S, dos Santos FO, Espindola MEV, Quadrado CTH, Lenharo NR & Quintino GG (2019). Pesticide dichlorvos alters the expression of hormonal receptors in rat ventral prostate. *Federation of American Societies for Experimental Biology,* **802**.77.

Rizzati V, Briand O, Guillou H & Gamet-Payrastre L (2016). Effects of pesticide mixtures in human and animal models: An update of the recent literature. *Chemico-Biological Interactions*, doi.10.1016/j.cbi.2016.06.003

Sorgob MAY & Vilanova E (2002). Enzymes involved in the detoxification of organophosphorus, carbamate and pyrethroid insecticides through hydrolysis. *Toxicology Letters*, **128**(1-3): 215-228.

Thredgold L, Gaskin S, Quy C & Pisaniello D (2019). Exposure of agriculture workers to pesticides: The effect of heat on protective glove performance and skin exposure to dichlorvos. *International Journal of Environmental Research and Public Health,* **16** (23): 4798.

Van Maele-Fabry G, Lantin AC, Hoet P & Lison D (2010). Childhood leukaemia and parental occupational exposure to pesticides: a systematic review and meta-analysis. *Cancer Causes & Control,* **21** (6): 787–809.

WHO (2011). The World Health Organization Recommended Classification of Pesticides by Hazard: International Programme on Chemical Safety. ISBN: 978 92 4 154796 3. http://www.who.int/ipcs/publications/pesticides_hazard/en/ retrieved 25-02-2020.

WHO (2020). The World Health Organization Recommended Classification of Pesticides by Hazardand Guidelines to Classification 2019.https://apps.who.int/iris/bitstream/handle/10665/332193/9789240005662-eng.pdf. retrieved 08-06-2020.

Yang J, Sun X, Feng Z, Hao D, Wang M, Zhao X & Sun C (2011). Metabolomic analysis of the toxic effects of chronic exposure to low-level dichlorvos on rats using ultra-performance liquid chromatography-mass spectrometry. *Toxicology Letters,* **206**(3): 306-13.

Yasmin S & D'Souza D (2010). Effects of Pesticides on the Growth and Reproduction of Earthworm: A Review. *Applied Environmental and Soil Science*, doi.10.1155/2010/678360.