



# Scientific Report on Pesticides in the Kenyan Market

## Submission from:

---

Biodiversity and Biosafety Association of Kenya (BIBA-K)  
Kenya Organic Agriculture Network (KOAN)  
Resources Oriented Development Initiatives (RODI)  
Route to Food Initiative (RTFI)

*Prepared by an expert task force  
September 2021*

---



## Table of Contents

<b>Introduction</b>	<b>1</b>
<b>Acknowledgements</b>	<b>2</b>
<b>Insecticides</b>	<b>3</b>
Acephate	4
Abamectin	9
Bifenthrin	15
Dichlorvos	20
Carbaryl	24
Carbofuran	28
Chlorpyrifos	32
Deltamethrin	38
Gamma-Cyhalothrin	43
Permethrin	46
Fenitrothion	52
Dimethoate	55
Flubendiamide	60
Flufenoxuron	63
Omethoate	66
Imidacloprid	69
Thiacloprid	76
Malathion	80
Pymetrozine	86
Oxydemeton-methyl	89
<b>Fungicides</b>	<b>92</b>
Chlorothalonil	93
Carbendazim	97
Thiophanate-methyl	102
Mancozeb	106
Tebuconazole	113

<b>Herbicides</b>	<b>117</b>
2,4-D Amine	118
Clodinafop	123
Oxyfluorfen	125
Glufosinate-ammonium	128

<b>Appendix 1. Methodology - Toxicity Scores</b>	<b>131</b>
--	------------

<b>Appendix 2. Toxicity score of active ingredients</b>	<b>133</b>
---	------------

## Introduction

In response to the recommendations made by the Departmental Committee on Health in their report dated 15th October 2020 on the Public Petition (No. 70 of 2019) regarding withdrawal of harmful chemical pesticides in the Kenyan market, the Pest Control Products Board (PCPB) is conducting a regulatory review of a priority list of active ingredients. BIBA, KOAN, RODI-Kenya and the RTFI, being the petitioners, have prepared this dossier upon request for public comments by the PCPB in their circular dated 6th July 2021 (PCPB/111/REG/VOL.I/21/135).

Continued population growth, and the resulting increases in development and expansion within the various agricultural sectors is leading to an even greater use of agrochemicals to meet the required demands of production (Ngaio, 2011<sup>1</sup>). The situation that has arisen with food safety concerns is symptomatic of a far more pervasive issue, namely that the Kenyan environment has, to all intents and purposes, been severely compromised by extensive input of chemical compounds and that the magnitude of such contamination remains largely undocumented. The studies that have been conducted intermittently have shown that often elevated residues of these agrochemicals are present in water sources used for domestic, livestock and irrigation purposes, in foodstuffs and animal products, and in human samples (e.g., breast milk). A retrospective study of poisoned patients admitted at Kenyatta National Hospital (KNH) over the period between January 2002 and June 2003 was carried out by Nyamu *et al.* (2012)<sup>2</sup>. Pesticides and household/industrial chemicals, the two most important poisoning agents, accounted for 43% and 24% of poisoning, respectively. Organophosphates and rodenticides were the two most common pesticides accounting for 57.4% and 31% of poisoning, respectively.

Considerably stronger efforts must also be directed towards investigating potential repercussions to human and environmental health after pesticides are legalised for agricultural application and from the pervasive practice of pesticide misuse in Kenya. While it is true that corporations which have benefited financially from both legal and illegal uses of their product must acknowledge responsibility and act accordingly, the Kenyan government ultimately bears responsibility for maintaining the safety of its own people and of the biodiversity upon whose integrity a significant component of the economy rests.

Within the course of compiling this dossier, we note that all of the active ingredients belong to the group of Highly Hazardous Pesticides (HHPs), but that there are several toxic pesticides registered for use in Kenya, that were not listed. These include atrazine, beta-cyfluthrin<sup>3</sup>, glyphosate, paraquat and triadimefon<sup>4</sup>. We recommend these active ingredients be included in the PCPB's review. While the pesticides industry claims that under safe use, there will be no human health or environmental harm, local research shows that safety measures are not applied by the farmer, because these measures are not communicated, not known, too expensive or not feasible in Kenya's operating context. The reality begs for increased investments in affordable biopesticides and training in Integrated Pest Management (IPM).

In addition, the European Commission (EC) has recently issued notifications of changes to plant protection product approvals within the European Union (EU) as follows<sup>5</sup>:

1. The EC published Implementing Regulation (EU) 2020/2087 in December 2020. As of 5 January 2021, mancozeb is no longer approved as an active substance in the EU.
2. The EU notified the World Trade Organisation (WTO) of its intention not to renew abamectin on 15 March 2021.

Non-renewal means that these PPPs can no longer be legally used within EU countries. This will have an impact on farmers in Kenya since the maximum residue levels (MRLs) will be reduced to the limit of determination (LoD), which in most cases means they can no longer be used on crops for export to the EU. Therefore, investments into looking for effective and available alternatives should be made as soon as possible.

Three categories for “**Proposed Action in Kenya**” have been defined in the dossier as follows:

- Active ingredient that must be withdrawn immediately
- Active ingredient for phased withdrawal as less toxic alternatives are developed and introduced

<sup>1</sup> Nyamu, D., Maitai, C.K., Mecca, L., & Mwangangi, E.M. (2012). Trends of acute poisoning cases occurring at the Kenyatta National Hospital, Nairobi, Kenya. *East and Central African Journal of Pharmaceutical Sciences*, 15, 29-34.

<sup>2</sup> Ngaio, R. (Ed.). (2011). *Carbofuran and Wildlife Poisoning: Global Perspectives and Forensic Approaches*. (1st ed.). John Wiley & Sons, Inc.

<sup>3</sup> Pesticide formulation that meets the criteria of Class IB (Highly Hazardous) of the WHO Recommended Classification of Pesticides by Hazard.

<sup>4</sup> Pesticide active ingredient listed in Annex III of the Rotterdam Convention on the prior informed consent procedure.

<sup>5</sup> Specific to the active ingredients listed in this dossier and currently under review by the PCPB.

- Active ingredient that may be retained, assuring that necessary mitigation measures, extensive training programs and IPM strategies are in place

The proposed action is informed by a toxicity index described in the appendices, as well as the common opinion of an expert task force<sup>6</sup>. We would like to emphasize that we call for action on pesticides active ingredients, and not just the withdrawal of certain products and companies. Active ingredients can be used in more than one product formulation, which means that harmful active ingredients can be manufactured in products trading under different names. We would also like to emphasize that toxic active ingredients should be substituted by less toxic ones, and that this information should be communicated to agrovet dealers and farmers, within a training and communication strategy targeting *all* farmers in Kenya.

## Acknowledgements

The petitioners wish to acknowledge the following experts of the task force who researched and prepared this dossier:

**Dr. Silke Bollmohr, Lead Researcher**, Ecotoxicologist and Managing Director of EcoTrac Consulting

**Dr. Allan Ndua Mweke, PhD**, Department of Animal Science and Production, Mount Kenya University

**Dr. Catherine Nkirote Kunyanga, PhD**, Department of Food Science, Nutrition and Technology, University of Nairobi

**Dr. Dino J. Martins, PhD**, Harvard University, Insect Committee of Nature Kenya

**Dr. Eliphas Gitonga Makunyi, PhD**, School of Public Health, Kenyatta University

**Dr. Macharia Ibrahim Ndegwa, PhD**, Department of Agricultural Economics, Kenyatta University

**Dr. Peterson Njogu Warutere, PhD**, Department of Environmental and Occupational Health, Kenyatta University

**Prof. Raphael Githaiga Wahome, PhD**, Department of Animal Production, University of Nairobi

**Mrs. Teresa Omwoyo**, School of Public Health, Department of Community Health and Epidemiology, Kenyatta University (pursuing PhD at Jomo Kenyatta University of Agriculture and Technology)

**Dr. Victor Ng'ani**, Bachelor of Medicine and Bachelor of Surgery (M.B.Ch.B) Group Head of Critical Care, RFH Healthcare

**Dr. Victor Shikuku, PhD**, Department of Physical Sciences, Kaimosi Friends University College

<sup>6</sup> The evidence submitted in 2019 alongside the Pesticides Petition included a detailed report on 8 active ingredients to be prioritised for withdrawal. Please note, the information has been captured here again and expanded upon, with the exception of paraquat which is excluded from the PCPB's current review




















# Insecticides



## Acephate

The active ingredient acephate is an organophosphate insecticide typically used as a foliar (relating to leaves) spray. Its breakdown product (metabolite) is methamidophos, which is not approved in Europe. Methamidophos is highly toxic to mammals and is an enzyme inhibitor and neurotoxin. It is highly toxic to birds and honeybees, and moderately toxic to most aquatic species and earthworms. In Kenya it is sold in **8 products** and is registered for controlling chewing and sucking insects in tobacco. It is only allowed for use on maize to control armyworm, but not on other vegetables. Nevertheless, acephate is being used on beans, tomatoes, and kale (KOAN, 2020).

General aspects	
<b>Registered products containing acephate</b>	Lotus 75% SP Soluble Powder Missile 75% SP Water Soluble Powder Orthene Pellet Ortran 97% Sinophate 75% SP Ace 750 Asataf SP Starthene Plus 97% DF
<b>Manufacturing companies</b>	Agrolex Private Ltd. / Nulandis Pty Ltd., South Africa Rallis Ltd., India Swal Corporation Ltd., India Devidayal Ltd, Nariman point, Mumbai, India Zhejiang Jiahua Chemical Co. Ltd., China Shanghai E-Tong Chemical Co. Ltd., China Ningbo Huili Imp. & Exp. Co. Ltd., China Arvesta Corporation, US
<b>Highly Hazardous Pesticide (HHP)</b>	Yes
<b>Withdrawn in Europe</b>	Yes
<b>Crops treated</b>	Maize
<b>Pest</b>	Armyworm
<b>Alternatives*</b>	Neem (Azadirachtin): Fortune, Magneto, Nimbecidine, Ozoneem, Neemark, Achook Pyrethroids Spinosad, Flubendiamide, Diflubenzuron, Chlorantraniliprole
Human Health**	
<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  



## Environmental Health\*\*

### Bee Toxicity



### Fish Toxicity



### Earthworm Toxicity



### Bird Toxicity



\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Generally, acephate is associated with hyperglycaemia, lipid metabolism dysfunction, DNA damage, and cancer, which are rapidly growing epidemics and which lead to increased morbidity and mortality rates and soaring health-care costs (Ribeiro *et al.*, 2016).

### Neurotoxicity and endocrine disrupting activity

Acephate can cause cholinesterase inhibition in humans as with any other organophosphate, which can result in overstimulation of the nervous system and which can cause nausea, dizziness, confusion, blurred vision, difficulty in breathing, muscle weakness and at very high exposures (e.g., accidents or major spills), respiratory paralysis, convulsion, coma and death (Mahaina *et al.*, 1997; Zinkl *et al.*, 1987; Farag *et al.*, 2000; Spassova *et al.*, 2000; Singh, 2002; Mash, 1999). Acephate also causes hormone expression in the hypothalamus (Singh, 2002) and can cause elevation of corticosterone and aldosterone (Ribeiro *et al.* 2016).

Chronic exposure causes personality changes and mental health conditions like depression and anxiety (New Jersey Department of Health, 2017).

### Carcinogenicity

It has been shown to cause liver cancer in animals. Many scientists believe there is no safe level (New Jersey Department of Health, 2017).

### Reproductive toxicity

Limited evidence exists on harm to the developing foetus (New Jersey Department of Health, 2017). However, it reduces sperm motility, capacitation and functional integrity of sperm cell membrane, and DNA damage and viability.

## Food safety issues

The degradation of the metabolite methamidophos takes a long time, therefore crops treated with acephate are unsafe for consumption except under stringent pre-harvest intervals (PHI). Therefore, it is recommended to increase the recommended PHI (Chai *et al.*, 2008). High residues of acephate and methamidophos were found on kale and tomatoes in Kirinyaga and Murang'a counties (KOAN, 2020).

Another study detected acephate in French beans, kales and tomatoes from urban and peri-urban areas of Nairobi and in tomatoes from Mwea Irrigation Scheme (Omwenga *et al.*, 2020; Nakhungu *et al.*, 2021). Acephate has also been reported in khat (*Catha edulis*) from Meru County at levels exceeding the Maximum Residue Limit (MRL) of the European Union (EU) for teas, and other herbal infusions from dried products (Krueger and Mutyam-bai, 2020).

## Environmental toxicity and environmental behavior of concern

The breakdown product methamidophos, is more toxic to bees, mammals and birds than acephate.

**Medium to high bee toxicity:** Chronic toxicity to honeybees was noticeable in body weight loss and esterase suppression, and its potential risk of synergistic interactions with other formulated pesticides (like chlorpyrifos,  $\lambda$ -cyhalothrin and oxamyl) (Yao *et al.*, 2018). It has been demonstrated to be toxic to stingless bees, other wild bees and hoverflies (Syrphidae), which are important pollinators of avocado in Kenya (Drescher and Pfister, 1990; Mulwa *et al.*, 2019, Diniz *et al.*, 2020). This reflects that the general recommendation of medium toxicity (done with European species) does not reflect the true toxicity to species relevant for Kenya.

**Medium to high bird toxicity:** Acute and chronic risk to birds and chronic risk to mammals are medium to high, depending on the species (Karath, 2014). Acephate-related health effects in wild birds are reduced eggs, egg hatching, and hatchling survival, and possibly disrupted migratory patterns (Zinkl *et al.*, 1984).

**Moderate aquatic toxicity:** Acephate is taken up rapidly by fish and other aquatic organisms and acts on the cholinesterase, but does not have any long-term effect on the fish population (Geen *et al.*, 1981; Zinkl *et al.*, 1987).

## Pesticides alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Endocrine disrupting activity towards farm workers
- High toxicity towards wild bees and stingless bees
- The breakdown product methamidophos is highly toxic to mammals, birds and bees
- Due to high human toxicity of methamidophos, no safe level is possible. Longer PHI to assure consumer safety
- High residues of acephate and methamidophos were found on kale, tomatoes, French beans, khat, teas and dried products compromising the food safety of Kenyan consumers
- Misuse by farmers associated with low literacy levels, lack of adequate information on product toxicity concerns, pesticides distribution infrastructure in Kenya (decanting from one container to another) amongst other factors

## References

- Chai, L. K., Mohd-Tahir, N., & Bruun Hansen, H. C. (2008). Dissipation of acephate, chlorpyrifos, cypermethrin and their metabolites in a humid-tropical vegetable production system. *Pest Management Science*, 65(2), 189–196. <https://doi.org/10.1002/ps.1667>
- Diniz, T.O., Pereira, N.C., Pizzaia, W.C.S., Sinópolis-Gigliolli, A.A., Silva, B.G., Borges, Y.M., Guedes, T.A. and Ruvolo-Takasusuki, M.C.C. (2020). Toxicity and genetic analysis of bees *Scaptotrigona bipunctata* after contamination with insecticide acephate. *Scientific Electronic Archives*, 13(8), 8-17.
- Drescher, W., & Geusen-Pfister, H. (1990). Comparative testing of the oral toxicity of acephate, dimethoate and methomyl to honeybees, bumblebees and Syrphidae. *VI International Symposium on Pollination* (pp. 133-138). International Society for Horticultural Science.
- Farag, A.T., Eweidah, M.H., & El-Okazy, A.M., (2000). Reproductive toxicology of acephate in male mice. *Reproductive Toxicology*, 14(5), 457-462. [https://doi.org/10.1016/S0890-6238\(00\)00094-0](https://doi.org/10.1016/S0890-6238(00)00094-0)
- Geen, G.H., Hussain, M.A., Oloffs, P.C., & McKeown, B.A., (1981). Fate and toxicity of acephate (Orthene) added to a coastal B. C. stream. *Journal of Environmental Science and Health*, 16(3), 253-271. [https://doi.org/10.1016/S0742-8413\(00\)00097-9](https://doi.org/10.1016/S0742-8413(00)00097-9)
- Kenyan Organic Agricultural Network (KOAN). 2020. *Pesticide use in Kirinyaga and Murang'a Counties*. <https://www.koan.co.ke/>
- Krueger, J. S., & Mutyambai, D.M. (2020). Restricting pesticides on a traditional crop: The example of khat (*Catha edulis*) and the Njuri Ncheke of Meru, Kenya. *Ecology and Society* 25(4). <https://doi.org/10.5751/ES-11916-250424>
- Mahaina, M., Quistad, G.B., & Casida, J.E., (1997). Acephate insecticide toxicity: Safety conferred by inhibition of the bioactivating carboxamidase by the metabolite methamidophos. *Chemistry Resolution and Toxicology*, 10(1), 64-69.
- Mash, E. A. (1999). *Encyclopedia of Toxicology*. Academic Press
- Mulwa, J., Kahuthia-Gathu, R., & Kasina, M., (2019). Avocado (*Persea americana*) yield as influenced by pollinators in Muranga County, Kenya. *Journal of Agricultural Research Advances*, 1(3). 34-41.
- Nakhungu, M. V., Margaret, N. K., Deborah, A. A., & Peterson, N. W., (2021). Pesticide Residues on Tomatoes Grown and Consumed in Mwea Irrigation Scheme, Kirinyaga County, Kenya. *Asian Journal of Agricultural and Horticultural Research*, 8(2), 1-11. <https://doi.org/10.9734/ajahr/2021/v8i230110>
- New Jersey Department of Health, (2017). *Hazardous substance fact sheet: Acephate*. <https://www.nj.gov/health/eoh/rtkweb/documents/fs/3140.pdf>
- Omwenga, I., Kanja, L., Zomer, P., Louisse, J., Rietjens, I. M. C. M., & Mol, H., (2020). Organophosphate and carbamate pesticide residues and accompanying risks in commonly consumed vegetables in Kenya. *Food Additives & Contaminants*. <https://doi.org/10.1080/19393210.2020.1861661>
- Ribeiro, T.A., *et al.* (2016). Acephate Exposure during a Perinatal Life Program to Type 2 Diabetes. *Toxicology*, 372, 12–21. <http://dx.doi.org/10.1016/j.tox.2016.10.010>.
- Singh, A.K., (2002). Acute effects of acephate and methamidophos and interleukin-1 on corticotropin-releasing factor (CRF) synthesis in and release from the hypothalamus in vitro. *Comparative Biochemistry and Physiology*, 132(1), 9-24. [https://doi.org/10.1016/S1532-0456\(02\)00020-0](https://doi.org/10.1016/S1532-0456(02)00020-0)
- Spassova, D., White, T., & Singh, A.K., (2000). Acute effects of acephate and methamidophos on acetylcholinesterase activity, endocrine system and amino acid concentrations in rats. *Comparative Biochemistry and Physiology*, 126(1), 79-89.

- Yao, J., Zhu, Y.C., Adamczyk, J., & Luttrell, R., (2018). Influences of acephate and mixtures with other commonly used pesticides on honey bee (*Apis mellifera*) survival and detoxification enzyme activities. *Comparative Biochemistry and Physiology*, 209, 9-17. <https://doi.org/10.1016/j.cbpc.2018.03.005>
- Zinkl, J.G., MacK, P.D., Mount, M.E., Shea, P.J., (1984). Brain cholinesterase activity and brain and liver residues in wild birds of a forest sprayed with acephate. *Environmental Toxicology and Chemistry* 3(1).
- Zinkl, J.G., Shea, P.J., Nakamoto, R.J., Callman, J., (1987). Effects of cholinesterases of rainbow trout exposed to acephate and methamidophos. *Bulletin of Environmental Contamination and Toxicology*, 38, 22-28.

## Abamectin

Abamectin is a member of avermectin family. It acts by stimulating the gamma-aminobutyric acid (GABA) system, which inhibits nerve to nerve, and nerve to muscle transmission. In Kenya it is sold in **38 products** and is registered for controlling chewing and sucking insects in mainly French beans and tomatoes but also in cabbage, broccoli, snow peas, chillies and potatoes. Farmers use abamectin on almost all crops (beans, cabbage, coffee, maize, rice, spinach and tomatoes) (KOAN, 2020).




























### General aspects

#### Registered products containing Abamectin

Abalone  
 Abamite  
 Acaramik  
 Acoster 5 EC  
 Adventure 5G  
 Agrimec 18 EC  
 Akrimactin 1.8EC  
 Almectin 1.8% EC  
 Alonze 50 EC  
 Amazing Top 100 WDG  
 Apex 40 EC  
 Armada 1.8 % EC  
 Avid 1.8 EC  
 Avirmec 1.8 EC  
 Barbican 10.2 EC  
 Bazooka 18EC  
 Chordata 10.2 EC  
 Deacarid 1.8EC  
 Dynamec 1.8 EC  
 Emperor Top 100 SC  
 Foscap 105 GR  
 Jundo 88 EC  
 Knockbectin  
 Knockbectin 40 EC  
 Konzano 50EC  
 Mitekill 2 EC  
 Murvectin EC  
 Oberon Speed  
 Romectin  
 Shark 40 EC  
 Summit 120 SC  
 Tervigo 20SC  
 Torpedo 1.8 EC  
 Trounce 20 SC  
 Twigamectin 18 EC  
 Vapcomic 1.8EC  
 Verkotin 1.8% EC  
 Zoro Tm 18EC

#### Manufacturing companies

Agrimore Enterprise Ltd, China  
 Arysta LifeScience Benelux Sprl, Belgium  
 Bayer AG, Germany  
 Beijing Yoloo Bio-Technology Corp., Ltd, China  
 Denka International BV-Netherlands and Almanda Israel Ltd.  
 Israel & Almadine Coporation SA Switzerland  
 Hailir Pesticides and Chemicals Group Co. Ltd., China  
 Handong Sino-Agri United Biotechnology Co., Ltd., China  
 Hebei Sony Chemical Co. Ltd  
 Hebei Vian Biochem Co. Ltd.,

<b>Manufacturing companies</b>	China / Cheminova A/S Denmark Jiangsu Qiaoji Biochem Co. Ltd., China jinan Shibang Agrochem Co. Ltd, China Ningbo Sunjoy Agroscience Co, China Rotam Agrochemicals, HongKong Shaanxi HengTian Chemical Co Ltd, China Shandong Sino-Agri United Biotechnology Co., Ltd., China Shijiazhuang Xingbai Bioengineering Co., Ltd., China Syngenta Crop Protection AG, Netherlands Syngenta Crop Protection AG, Switzerland / Syngenta East Africa Ltd VAPCO (Veterinary and Agricultural Products Manufacturing Company Ltd., Jordan Willowood United, China / Fluence Middle East Africa Yunnan Guangmin Neem Industries Ltd. China Zhejiang Qianjiang Biochemical Co. Ltd. China Zhejiang Shengua Bick Biology Co., China
<b>HHP</b>	Yes
<b>Withdrawn in Europe</b>	Yes
<b>Crops treated</b>	Tomatoes, Cabbages, French beans, Broccoli, Snow peas, Potatoes, Chillies
<b>Pest</b>	Red spider mites, Leaf miners, Thrips, Aphids
<b>Alternatives*</b>	Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur
<b>Human Health**</b>	
<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  
<b>Environmental Health**</b>	
<b>Bee Toxicity</b>	  
<b>Fish Toxicity</b>	  
<b>Earthworm Toxicity</b>	  
<b>Bird Toxicity</b>	  



\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Acute exposure (poisoning) to abamectin causes nausea, vomiting, diarrhoea, sleepiness, agitation, and weakness; in severe poisoning, hypotension, tachycardia, coma, and respiratory failure are described (Selladurai, *et al.*, 2021). Severely poisoned patients suffer unconsciousness, hypotension, metabolic acidosis, and even death (Bansod *et al.*, 2013). Severe abamectin ingestions outcomes were observed in six patients with one late death due to multi-organ failure which occurred after 18 days (Selladurai, *et al.*, 2021). The main cause of death caused by abamectin is respiratory failure (Sung *et al.*, 2009). Abamectin poisoning can induce brain cell apoptosis and affect the normal functioning of the nervous system (Dalzell *et al.*, 2015). Clinically, hyperactivity, irritability, coma, and respiratory depression may occur (Li *et al.*, 2010).

### Neurotoxin and respiratory failure

Abamectin causes neurotoxicity and respiratory failure (Bansod *et al.*, 2013). Major adverse effects of abamectin are observed with neurological symptoms such as tremor, convulsion, and mydriasis (FSCJ, 2016). The severity of abamectin poisoning manifestations depends on the dose ingested. High doses of abamectin can penetrate the blood–brain barrier leading to coma, and changes in mental status can be considered as the first sign of abamectin poisoning. The improvement of consciousness level is the best indicator of disease improvement (Aminiahidashti *et al.*, 2014).

Acute and chronic injuries to the brain, affect the cerebral hemispheres, cerebellum, and brain stem. Clinical manifestations depend on the nature of injury. Diffuse trauma to the brain is frequently associated with diffuse axonal injury or coma, post-traumatic. Localized injuries may be associated with neurobehavioral manifestations; hemiparesis, or other focal neurologic deficits (National Center for Biotechnology Information, 2021).

There are three main mechanisms of neurotoxic effects, which promote the release of aminobutyric acid (GABA), reduce the activity of metabolic enzymes in brain cells, and induce apoptosis of brain cells (Dalzell *et al.*, 2015). Abamectin upregulates the GABA-A receptor in the brain (Radi *et al.*, 2020). FSCJ (2016) considers that abamectin causes tremor/convulsion through the GABA-ergic action with hyperpolarization of nerve/muscle cells. Abamectin is related to the inhibition of mitochondrial activity, which leads to decreased synthesis of ATP followed by cell death (Maioli *et al.*, 2013). Abamectin-induced oxidative stress is one of the main reasons for the DNA damage that occurs in cells (Liang *et al.*, 2020).

### Reproductive toxicity

The European Food Safety Authority (2015) identified two studies reporting potential negative reproductive effects from abamectin exposure when used in crop protection (Celik-Ozenci *et al.*, 2011, 2012). Decreased sperm quality and/or motility was reported in humans or rats following exposure to abamectin (Celik-Ozenci *et al.*, 2011, 2012).

## Food safety issues

Residues of avermectin family members used in veterinary pharmaceuticals to control parasites have been found in animal products such as meat and milk. The MRL of abamectin and ivermectin for milk in cattle is 0.005 mg kg<sup>-1</sup> and 0.01 mg kg<sup>-1</sup>, respectively (Codex, 2015). The half-life of abamectin and ivermectin varies between 2 and 4 days in milk (Imperiale *et al.*, 2004; Cerkenik-Flajs *et al.*, 2007). However, abamectin and ivermectin have been detected in milk up to 23 days and 21 days post treatment following oral and subcutaneous treatment (Imperiale *et al.*, 2004; Cerkenik-Flajs *et al.*, 2007). Therefore, it has been suggested to avoid using milk and its products within 30 days post cattle treatment (Cerkenik-Flajs *et al.*, 2007).

High concentrations of abamectin pesticide residues have been reported in green pepper and courgette from Algeria (Belguet *et al.*, 2019) and in apples from China (Guo *et al.*, 2021) and in green beans (Badaway *et al.*, 2020). Monitoring results from Kenya are lacking.

Abamectin should be categorized as a substrate of concern that requires monitoring in food (Nougadere *et al.*, 2011).

## Environmental toxicity and environmental behavior of concern

**High bee toxicity:** Abamectin has an adverse effect on honeybees, especially foragers honeybee workers. There is a clear impact on the lethal time and effects on midgut cells that may cause digestive disorders in the midgut, slowing its efficiency and thus affecting honeybee colonies' health and vitality (Aljedani, 2017). It has been documented that abamectin has an impact on stingless bees and wild bees (Del Sarto *et al.*, 2014; do Prado *et al.*, 2020, Aljedani, 2017; Brigante *et al.*, 2021).

In Kenya this could impact stingless bees that are very important wild pollinators and occur in many agricultural matrix zones. There are differences in impact based on the kind of exposure or ingestion involved.

**Low to medium bird toxicity:** Acute and chronic risks to birds and chronic risk to mammals are depending on the species. (Aljedani, 2017). Exposure leads to both acute, chronic toxicity and anti-predatory behavior deficit (de Faria *et al.*, 2018)

**High aquatic toxicity:** Exposure led to a prominent toxic effect, immunological activity inhibition and genotoxicity (Huang *et al.*, 2019). Thus it is highly toxic to fish and extremely toxic to aquatic invertebrates (US Environmental Protection Agency., 2016), as it can pass the blood-brain barrier in some aquatic species (Novelli *et al.*, 2012). This means, if water is contaminated through run-off and/or accidental introduction, abamectin becomes a major source of concern for some aquatic species. Abamectin can runoff from the sites of application and becomes an aquatic pollutant.

Based on the available literature, soil contamination with abamectin may be a source of concern (Jochmann and Blanckenhorn, 2016).

## Pesticide's alternatives

Overall, spirotetramat is considered to be safe to most beneficial insects (Salazar-López *et al.*, 2016) and for this reason can be considered a valuable alternative to abamectin. For others see table above.

## Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced.

Proposed withdrawal in Kenya should be based on:

- High neurotoxicity and reproductive toxicity
- High toxicity towards wild bees and stingless bees
- High toxicity towards fish species



## References

- Aljedani, D. M., (2017). Effects of abamectin and deltamethrin to the foragers honeybee workers of *Apis mellifera jemenatica* (Hymenoptera: Apidae) under laboratory conditions. *Saudi Journal of Biological Sciences*, 24(5), 1007–1015. <https://doi.org/10.1016/j.sjbs.2016.12.007>.
- Aminiahidashti, H., Jamali, S.R., and Heidari, Gorji A.M., (2014). Conservative care in successful treatment of abamectin poisoning. *Toxicology International*, 21(3), 322–334.
- Badawy, Mohamed E. I., Mahmoud, Mostafa, S., Khattab, Marium M., (2020). Residues and dissipation kinetic of abamectin, chlorfenapyr and pyridaben acaricides in green beans under field conditions using QuEChERS method and HPLC. *Journal of Environmental Science and Health*. doi:10.1080/03601234.2020.1726701
- Bansod, Y.V., Kharkar, S. V., Raut, A., Choudalwar P., (2013). Abamectin: An uncommon but potentially fatal cause of pesticide poisoning. *Int J Res Med Sci*, 1, 285-6.
- Belguet, A., Dahamna, S., Abdessemed, A., Ouffroukh, K., Guendouz, A., (2019). Determination of abamectin pesticide residues in green pepper and courgette growing under greenhouse conditions (Eastern of Algeria –Setif–). *Eurasian Journal of Biosciences*, 13(2), 1741-1745
- Brigante, J., Costa, J.O., Espíndola, E.L. and Daam, M.A., (2021). Acute toxicity of the insecticide abamectin and the fungicide difenoconazole (individually and in mixture) to the tropical stingless bee *Melipona scutellaris*. *Ecotoxicology*, 1-8.
- Celik-Ozenci, C., Tasatargil, A., Tekcan, M., Sati, L., Gungor, E., Isbir, M., Demir, R., (2011). Effects of abamectin exposure on male fertility in rats: potential role of oxidative stress-mediated poly (ADP-ribose) polymerase (PARP) activation. *Regul. Toxicol. Pharmacol.*, 61.
- Celik-Ozenci, C., Tasatargil, A., Tekcan, M., Sati, L., Gungor, E., Isbir, M., Usta, M., Akar, M., Erler, F., (2012). Effect of abamectin exposure on semen parameters indicative of reduced sperm maturity: a study on farm-workers in Antalya (Turkey). *Andrologia*, 44.
- Cerkvenik-Flajs, V., Grabnar, I., Kozuh Erzen, N., Marc, I., Antonic, J., Vergles-Rataj, A., Kuzner, J., Pogacnik, M., (2007). Kinetics of abamectin disposition in blood plasma and milk of lactating dairy sheep and suckling lambs. *J. Agric. Food Chem.*, 55.
- Codex, 2015. Veterinary Drug Residues in Food Updated up to the 38th Session of the Codex Alimentarius Commission. <http://www.fao.org/fao-who-codexalimentarius/standards/veterinary-drugs-mrls/en/>
- Dalzell AM., Mistry P., Wright J, *et al.*, (2015). Characterization of multidrug transporter-mediated efflux of avermectins in human and mouse neuroblastoma cell lines. *Toxicology Letters*, 235(3), 189–198.
- de Faria DBG., Montalvão MF., Chagas TQ., Araújo APC., Souza JM., Mendes BO., Rodrigues ASL., Malafaia G., (2018). Behavioral changes in Japanese quails exposed to predicted environmentally relevant abamectin concentrations. *Sci Total Environ*; 636,1553-1564. doi: 10.1016/j.scitotenv.2018.04.293
- Del Sarto, M.C.L., Oliveira, E.E., Guedes, R.N.C. and Campos, L.A.O., (2014). Differential insecticide susceptibility of the Neotropical stingless bee *Melipona quadrifasciata* and the honey bee *Apis mellifera*. *Apidologie*, 45(5), 626-636.
- do Prado, F.S.R., Dos Santos, D.M., de Almeida Oliveira, T.M., Burgarelli, J.A.M., Castele, J.B. and Vieira, E.M., (2020). Determination and uptake of abamectin and difenoconazole in the stingless bee *Melipona scutellaris* Latreille, via oral and topic acute exposure. *Environmental Pollution*, 265.
- Food Safety Commission of Japan (FSCJ) (2016) Abamectin: Avermectin (Pesticides). Food safety (Tokyo, Japan) 4(1): 30–31.
- Guo, Z., Su, Y., Li, K. *et al.* (2021). A highly sensitive octopus-like azobenzene fluorescent probe for determination of abamectin B1 in apples. *Sci Rep* 11, 4655. <https://doi.org/10.1038/s41598-021-84221-w>
- Huang, Y., Hong, Y., Huang, Z., Zhang, J., Huang, Q., (2019). Avermectin induces the oxidative stress, genotoxicity, and immunological responses in the Chinese Mitten Crab, *Eriocheir sinensis*. doi: 10.1371/journal.pone.0225171.
- Imperiale, F., Lifschitz, A., Sallovitz, J., Virkel, G., Lanusse, C., (2004). Comparative depletion of ivermectin and moxidectin milk residues in dairy sheep after oral and subcutaneous administration. *J. Dairy Res.*, 71.

- Jochmann, R., Blanckenhorn, W.U., (2016). Non-target effects of ivermectin on trophic groups of the cow dung insect community replicated across the agricultural landscape. <http://dx.doi.org/10.1016/j.baae.2016.01.001>.
- Kenyan Organic Agricultural Network (KOAN). 2020. *Pesticide use in Kirinyaga and Murang'a Counties*. <https://www.koan.co.ke/>
- Li, T., Long, H., Wen, H.L., *et al.*, (2010). Toxicological mechanism and toxic treatment of abamectin. *Medical Re-capitulate* 16(10), 1555–1555.
- Liang, YR., Dong, BZ., Pang, NN., *et al.*, (2020). Abamectin induces cytotoxicity via the ROS, JNK, and ATM/ATR pathways. *Environmental Science and Pollution Research International* 27(12), 13726–13734.
- Maioli, MA., Medeiros, HC., Guelfi, M., *et al.* (2013) The role of mitochondria and biotransformation in abamectin induced cytotoxicity in isolated rat hepatocytes. *Toxicology In Vitro* 27(2), 570–579.
- Nougadere, A., Reninger, J.-C., Volatier, J.-L., Leblanc, J.-C., (2011). Chronic dietary risk characterization for pesticide residues: a ranking and scoring method integrating agricultural uses and food contamination data. *Food Chem. Toxicol.* 49.
- National Center for Biotechnology Information (2021). PubChem Compound Summary for CID 6435890, Abamectin. Retrieved September 2, 2021 from <https://pubchem.ncbi.nlm.nih.gov/compound/Abamectin>.
- Radi, AM., Mohammed, ET., & Abushouk, AI., *et al.* (2020). The effects of abamectin on oxidative stress and gene expression in rat liver and brain tissues: modulation by sesame oil and ascorbic acid. *The Science of the Total Environment*, 701.
- Salazar-López, Norma & Aldana, Lourdes & Silveira-Gramont, María-Isabel & Aguiar, José-Luis. (2016). Spirotetramat — An Alternative for the Control of Parasitic Sucking Insects and its Fate in the Environment. 10.5772/61322.
- Selladurai Pirasath, Balasubramaniam Nageswaran, Rankiri Pathirannahalage Vasana Karunasena & Mathyasekeran Gevakaran., (2021). Acute abamectin toxicity: A case report. *Toxicology Communications*, 5(1), 66-68, DOI: 10.1080/24734306.2021.1881233.
- Sung, YF., Huang, CT., Fan, CK., *et al.* (2009) Avermectin intoxication with coma, myoclonus, and polyneuropathy. *Clinical Toxicology* 47(7), 686–688.
- US Environmental Protection Agency. Pesticide Fact Sheet Number 89.2: Avermectin B1. Office of Pesticides and Toxic Substances, Washington, DC, 1990.10-143.

## Bifenthrin

Bifenthrin is a pyrethroid insecticide. In Kenya it is sold in **8 products** and is registered for controlling a range of pests on various crops (French beans, snow peas, barley, tomatoes, onions). Farmers in Kenya mainly use bifenthrin on maize (KOAN, 2020).

General aspects	
Registered products containing Bifenthrin	Biferan 25EC Bridge 80SC Brigade 25EC Defender 2.5% EC Disect 10 EC Seizer 80SC Super grain dust Talstar 100 EC
Manufacturing companies	FMC Corporation USA FMC Europe, Belgium. FMC Corporation, USA. Agroshine (Hangzhou) Udragon Chemical Co. Ltd, China
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	French beans, Snow peas, Citrus, Barley, Tomatoes, Onions
Pest	Aphids, Whiteflies, Thrips, Caterpillars, Leaf miners, Spider mites, Bollworms, Diamond back moth
Alternatives*	Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin)  Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur, Teflubenzuron, Etofenprox
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  

**Environmental Health\*\*****Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern**

The health implications of bifenthrin include respiratory and nasal irritation, headache, dizziness, nausea, allergies, asthma, nasal discharge, bronchitis, sinusitis, and sneezing. It is also a possible carcinogenic, an endocrine disrupter and affects the nervous system of humans (Ahmed *et al.*, 2011).

**Neurotoxicity**

Bifenthrin belongs to Type I pyrethroid insecticides interacting with voltage-gated sodium channels in neuron membranes. It is neurotoxic. Intoxication leads to death in target organisms. There is evidence that pyrethroid intoxication in mammals (humans and animals) may lead to health problems (Chandra, 2013). Acute poisoning with bifenthrin in mammals produces aggressive sparring, sensitivity to stimuli and tremor (Cao, 2011).

**Hepatotoxicity**

Bifenthrin undergoes oxidative metabolism leading to the formation of 4'-hydroxy-bifenthrin and hydrolysis hepatic microsomes in rodents as well as in humans (Park *et al.*, 2020; Nallani *et al.*, 2018).

**Food safety issues**

It is highly persistent and bioaccumulates in the environment (EFSA, 2011) thus the reason for its presence in fruits and vegetables. Many researchers have observed its long persistence under aerobic and anaerobic conditions. It degrades slowly in the soil due to its long half-life (Zhang *et al.*, 2007). Wolanksy *et al.*, (2016) stated there is a risk of chronic exposure to humans through pesticide residues in food products due to its bioaccumulation potential. Bifenthrin occurrence has also been reported in tea from Pakistan at levels above allowable limits (Yaqub *et al.*, 2018) and in okra fruits from India (Kumari *et al.*, 2013). Bifenthrin has recently been detected in tomatoes from market outlets in peri-urban areas of Nairobi, Thika, Nakuru and Machakos counties in Kenya at concentrations above the MRL (>0.05mg/kg) (Kunyanga *et al.*, 2018).

**Environmental toxicity and environmental behavior of concern**

**High bee toxicity:** It has been shown that bifenthrin is very toxic to honeybees as well as other beneficial insects. However, there are limited studies on the wider pollinator/biodiversity impacts (Main *et al.*, 2016; Dai *et al.*, 2010; Peterson *et al.*, 2021).

**Aquatic toxicity:** Bifenthrin can potentially enter surface waters through a variety of mechanisms depending on the product type used. These include spray drift, particle transport or via storm water runoff. It has been determined that bifenthrin is highly toxic to fish and aquatic invertebrates and therefore it is a restricted-use pesticide (USEPA, 2004) and withdrawn in Europe because of its aquatic toxicity. Bifenthrin has been detected in various aquatic settings including agricultural drains, creeks, rivers, open wells, nursery runoff, channels, and even golf course ponds in Europe and the US (Kelley and Starnier, 2004; LeBlanc *et al.*, 2004; Hunt *et al.*, 2006; Smith Jr. *et al.*, 2006). Surface water concentrations of bifenthrin ranged from 0.005 to 3.79 µg/L with the highest concentration measured in the Hines Channel in California (Siepmann and Holm, 2000).

Bifenthrin is highly toxic to fish, crustaceans and aquatic animals (Riar, 2014). It hinders metabolic processes and shows endocrine signals and lower reproductive performance (Brander *et al.*, 2016). There are publications about the immunotoxic effects of bifenthrin on zebrafish embryos. In the experiment conducted by Jin *et al.* it was shown that exposure to bifenthrin increased the level of interleukin 1β, interleukin 8, caspase 9 and 3 in embryos ex-



posed to S-cis- bifenthrin (Jin *et al.*, 2013). Park *et al.* (2020) confirmed that bifenthrin intoxication during zebrafish embryogenesis induced developmental toxicity, inflammation and decreases angiogenesis.

**Low to medium bird toxicity:** Bifenthrin insecticide exerted toxic effects in exposed pigeons and can produce moderate to severe hepatic alterations in the avian species in proportion to exposure level and duration (Shakeel *et al.*, 2015).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Concerns about bioaccumulation
- Endocrine disrupter with high neurotoxicity
- High toxicity towards bees
- High toxicity towards fish species
- Some toxicity towards earthworms
- Food safety concerns




























## References

- Ahmed, M., (2011). Monitoring of multiple pesticide residues in some fruits in Karachi, Pakistan. *Pak. J. Bot*, 43(4), 1915-1918.
- Brander SM, Jeffries KM, Cole BJ, DeCourten BM, White JW, Hasenbein S, Fangué NA, Connon RE. (2016). Transcriptomic changes underlie altered egg protein production and reduced fecundity in an estuarine model fish exposed to bifenthrin. *Aquat Toxicol*. 174. doi: 10.1016/j.aquatox.2016.02.014.
- Cao Z, Shafer TJ, Crofton KM, Gennings C, Murray T.F., (2011). Additivity of pyrethroid actions on sodium influx in cerebrocortical neurons in primary culture. *Environ Health Perspect*. 199, 1239–46.
- Chandra A, Dixit MB, Banavaliker JN., (2013). Prallethrin poisoning a diagnostic dilemma. *J Anaesthesiol Clin Pharmacol*. 29:121–2.
- Dai, P.L., Wang, Q., Sun, J.H., Liu, F., Wang, X., Wu, Y.Y. and Zhou, T., (2010). Effects of sublethal concentrations of bifenthrin and deltamethrin on fecundity, growth, and development of the honeybee *Apis mellifera ligustica*. *Environmental Toxicology and Chemistry: An International Journal*, 29(3), 644-649.
- EFSA (European Food Safety Authority), (2011). Peer Review Report to the conclusion regarding the peer review of the pesticide risk assessment of the active substance bifenthrin.
- Hunt, J., Anderson, B., Phillips, B., Tjeerdema, R., Richard, N., Connor, V., Worcester, K., Angelo, M., Bern, A., Fulfroost, B., Mulvaney, D., (2006). Spatial relationships between water quality and pesticide application rates in agricultural watersheds. *Environ. Monit. Assess*. 121, 243–260.
- Jin, Y., Pan, X., Cao, L., Ma, B., Fu, Z., (2013). Embryonic exposure to cis-bifenthrin enantio selectively induces the transcription of genes related to oxidative stress, apoptosis and immunotoxicity in zebrafish (*Danio rerio*). *Fish Shellfish Immunol.*, 34:717–23.
- Kelley, K., Starner, K., (2004). Preliminary Results for Study 219: Monitoring Surface Waters and Sediments of the Salina and San Joaquin River Basins for Organophosphate and Pyrethroid Pesticides. California Environmental Protection Agency.
- KOAN-Kenyan Organic Agricultural Network, 2020. Pesticide use in Kirinyaga and Murang'a Counties. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf)
- Kumari, Sachin & Chauhan, Reena & Prakash, Ram & Kumari, Beena. (2013). *African Journal of Agricultural Research Persistence and decontamination of bifenthrin residues in okra fruits*. 10.13140/ RG.2.2.12384.92160.
- Kunyanga C., Amimo J., Kingori L., Chemining'wa G., (2018). Consumer Risk Exposure to Chemical and Microbial Hazards
- LeBlanc, L.A., Orlando, J.L., Kuivila, K.M., (2004). Pesticide Concentrations in Water and in Suspended and Bottom Sediments in the New and Alamo Rivers, Salton Sea, Watershed California, April 2003. US Geological Survey Reston, Virginia.
- Main, A.R., Hladik, M.L., Webb, E.B., Goyne, K.W. and Mengel, D., (2020). Beyond neonicotinoids—Wild pollinators are exposed to a range of pesticides while foraging in agroecosystems. *Science of the Total Environment*, 742, p.140436.
- Nallani, GC., Chandrasekaran, A., Kassahun, K., Shen, L., El Naggat, SF., Liu, Z., (2018). Age dependent in vitro metabolism of bifenthrin in rat and human hepatic microsomes. *Toxicol Appl Pharmacol.*, 338:65–72.
- Park, S., Lee, J.Y., Park, H., Song, G., Lim, W., (2020). Bifenthrin induces developmental immunotoxicity and vascular malformation during zebrafish embryogenesis. *Comp Biochem Physiol C Toxicol Pharmacol*. <https://doi.org/10.1016/j.cbpc.2019.108671>
- Peterson, E.M., Green, F.B. and Smith, P.N., (2021). Toxic responses of blue orchard mason bees (*Osmia lignaria*) following contact exposure to neonicotinoids, macrocyclic lactones, and pyrethroids. *Ecotoxicology and Environmental Safety*, 208, p.111681. Research. Vol. 8(38), pp. 4833-4838
- Riar, N.K. (2014). Bifenthrin. *Encyclopedia of Toxicology*, 449-451 <https://doi.org/10.1016/B978-0-12-386454-3.01169-6>

- Shakeel, M. (2015). Patho-biochemical biomarkers of hepatotoxicity on exposure to bifenthrin insecticide in birds (*Columba livia*). *Pure and Applied Biology*. 4. 597-604. 10.19045/bspab.2015.44019.
- Siepmann, S., Holm, S., (2000). Hazard Assessment of the Synthetic Pyrethroid Insecticides Bifenthrin, Cypermethrin, Esfenvalerate, and Permethrin to Aquatic Organisms in the Sacramento-San Joaquin River system. Resources Agency, Department of Fish and Game.
- Smith, Jr, S., Cooper, C.M., Lizotte Jr., R.E., Shields Jr., F.D., (2006). Storm pesticide concentrations in Little Topashaw Creek, USA. *Int. J. Ecol. Environ. Sci.* 32, 173– 182.
- USEPA, Washington, DC. Weston, D.P., You, J., Lydy, M.J., (2004). Distribution and toxicity of sediment associated pesticides in agriculture-dominated water bodies of California's central valley. *Environ. Sci. Technol.* 38, 2752–2759.
- Wolansky, M.J., Gennings, C., Crofton, K.M., (2006). Relative potencies for acute effects of pyrethroids on motor function in rats. *Toxicol Sci.* 89:271–7).
- Yaqub G., Fizza I., Muniba I., Vania M. (2018). Monitoring and risk assessment due to presence of heavy metals and pesticides in tea samples. *Food Sci. Technol* 38 (4), 625-628
- Zhang, H. Y., Gao, R. T., Huang, Y. F., Jia, X. H., & Jiang, S. R. (2007). Spatial variability of organochlorine pesticides (DDTs and HCHs) in surface soils from the alluvial region of Beijing, China. *Journal of Environmental Sciences*, 19(2), 194-199

## Dichlorvos

Dichlorvos is an organophosphate fumigant insecticide. In Kenya it is registered in only **one product** to control sucking insect pests on coffee.

General aspects	
Registered products containing Dichlorvos	Divipan 100F
Manufacturing companies	Adama Makhteshim Ltd
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Coffee
Pest	Mites, Aphids, Thrips
Alternatives*	Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021  
 \*\* Pesticide Properties Database: University of Hertfordshire, 2021  
 Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Dichlorvos is toxic following acute oral and dermal exposure and very toxic after acute inhalation exposure. Short term exposure causes headaches, fatigue, loss of memory, and convulsions (Khan *et al.*, 2020). It is slightly irritant to the skin and eyes. It is also a skin sensitizer (EFSA, 2006).

### Genotoxic effect

Dichlorvos has been reported not to be genotoxic in vivo in animal studies (Nazam *et al.*, 2013). However, in an in vitro study, Fiore *et al.* (2013) reported disruption of mitotic division, production of mitotic arrest and chromosome aneuploidy/polyploidy in the proliferation of cell population in human cell culture by dichlorvos.

### Immunological effect/Endocrine disruption

Long term exposure can weaken the immune system and causes endocrine disruption (Zhao *et al.*, 2015)

There is evidence from occupational exposures that dichlorvos has the potential to cause skin sensitization. Human diagnostic patch tests of occupational flower growers with a history of pesticide dermatitis have shown an allergic contact dermatitis response to dichlorvos (NIOSH, 2017).

### Hepatic effect

Zhao *et al.*, (2015) reported a case of dichlorvos induced autoimmune hepatitis in a 49-year-old Chinese woman following chronic exposure to dichlorvos. The diagnosis was made two and a half years after initial symptoms of exposure. On initial admission, she was presented with alanine transaminase (ALT) 1558 U/L (Normal: 5–40 U/L), aspartate transaminase (AST) 1267 U/L (normal: 10–40 U/L), total bilirubin (TBIL) 133.5 µmol/L (normal: 3–20 µmol/L, alkaline phosphatase (AKP) 182 U/L (normal: 15–130 U/L).

### Respiratory effect

Respiratory irritation following dichlorvos exposure was reported in a study (Mathur *et al.*, 2000) involving children. The study reported strong correlation between acute respiratory symptoms and exposure to dichlorvos. However, the authors could not rule out irritant effects of the solvents used to disperse the dichlorvos.

### Carcinogenic

It is classified by the International Agency for Research on Cancer (IARC) as Group 2B, possibly carcinogenic to humans.

### Neurotoxicity

It belongs to the organophosphate group and affects the nervous system.

## Food safety issues

High levels of residues were detected in food in Zambia (Mwanja *et al.*, 2017). Residues on crops can persist for 15 days after application (Stephen, D. and Meera, S., 2010). Dichlorvos has been reported in vegetables from Arusha at levels exceeding the stipulated MRL (Kiwango *et al.*, 2018a) and also in ready-to-eat vegetables at household level (Kiwango *et al.*, 2019). Dichlorvos has also been reported in food samples (legumes, cereals, tubers) from Nigeria, Cameroon and Benin (Luc *et al.*, 2019). Dichlorvos concentrations above MRLs were also reported in parsley, lettuce and spinach from Hatay Province in Turkey (Esturk *et al.*, 2014).

## Environmental toxicity and environmental behavior of concern

Dichlorvos has a high aqueous solubility, quite volatile and, based on its chemical properties, is unlikely to leach to groundwater (Lewis *et al.*, 2016). Dichlorvos shows a low persistence in soil (Erdoğan *et al.*, 2002)

**High bee toxicity:** Dichlorvos is highly toxic to honeybees (*Apis mellifera*) (via topical application or oral dosing) (Lewis *et al.*, 2016). It is known to slow bee maturation process (The Pesticide Manual, 2000). There is evidence that high usage has been linked with loss of pollinators in some parts of the world (Ratnakar *et al.*, 2017; Partap *et al.*, 2000).

**High aquatic toxicity:** It is neurotoxic to freshwater and marine fish, as well as invertebrates due to negative effects on energy metabolism. Bui-Nguyen *et al.* (2015), illustrated various kinds of effects on energy utilization and stress response in the liver of zebrafish. There are insufficient data to assess the comprehensive risk to aquatic organisms (EFSA, 2006).

**Medium to high toxicity to birds:** Extremely poisonous to birds (Regenstrief Institute, 2021).

## Pesticide's alternatives

Spinosad was evaluated in Hawaii as a replacement for organophosphate insecticides in methyl eugenol and cue-lure bucket traps to attract and kill oriental fruit fly, *Bactrocera dorsalis* Hendel, and melon fly, *B. cucurbitae* Coquillett, respectively (Vargas *et al.*, 2005)

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Dichlorvos is a probable mutagen, a neurotoxin and may damage reproduction and/or development
- High bee toxicity
- High aquatic toxicity
- It is highly toxic to mammals and has a high tendency to bioaccumulate on crops




























## References

- Bui-Nguyen, Tri & Baer, Christine & Lewis, John & Yang, Dongren & Lein, Pamela & Jackson, David. (2015). Dichlorvos exposure results in large scale disruption of energy metabolism in the liver of the zebrafish, *Danio rerio*. *BMC genomics*. 16. 853. 10.1186/s12864-015-1941-2.
- Erdoğan, M., (2002). Investigation of dichlorvos (DDVP) and trifluralin pesticide levels in Tahtalı Dam Water (Master's thesis, İzmir Institute of Technology).
- Esturk, O., Yakar, Y. & Ayhan, Z. (2014). Pesticide residue analysis in parsley, lettuce and spinach by LC-MS/MS. *J Food Sci Technol* 51, 458–466. <https://doi.org/10.1007/s13197-011-0531-9>
- European Food Safety Authority (EFSA), (2006). Conclusion regarding the peer review of the pesticide risk assessment of the active substance dichlorvos. *Efsa Journal*, 4(6), 77r.
- Fiore, Mario & Mattiuzzo, Marta & Mancuso, Graziella & Totta, Pierangela & degrassi, Francesca. (2013). The pesticide dichlorvos disrupts mitotic division by delocalizing the kinesin Kif2a from centrosomes. *Environmental and molecular mutagenesis*. 54. 10.1002/em.21769.
- Khan, Nikhat & Yaqub, Ghazala & Hafeez, Tahreem & Tariq, Madiha. (2020). Assessment of Health Risk due to Pesticide Residues in Fruits, Vegetables, Soil, and Water. *Journal of Chemistry*. 2020. 1-7. 10.1155/2020/5497952..
- Kiwango, PA., Kassim, N., Kimanya ME., (2018a). The risk of dietary exposure to pesticide residues and its association with pesticide application practices among vegetable farmers in Arusha, Tanzania. *J Food Res*. 7(2). doi:10.5539/jfr. v7n2p86.
- Kiwango PA, Kassim N, Kimanya ME., (2019). Household vegetable processing practices influencing occurrence of pesticide residues in ready-to-eat vegetables. *J Food Safety*. DOI: 10.1111/jfs.12737
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A., (2016). An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- Luc I., Renwei H., Lionel L., Anaïs P., (2019). Sub-Saharan Africa total diet study in Benin, Cameroon, Mali and Nigeria: Pesticides occurrence in foods. *Food Chemistry: X*, 2, <https://doi.org/10.1016/j.fochx.2019.100034>
- Mathur ML, Yadev SP, Tyagi BK. A study of an epidemic of acute respiratory disease in Jaipur town. *J Postgrad Med*. 2000; 46(2):88–90.
- Mwanja, M., Jacobs, C., Mbewe, A.R. *et al.* (2017). Assessment of pesticide residue levels among locally produced fruits and vegetables in Monze district, Zambia. *Food Contamination* ,4, 11. <https://doi.org/10.1186/s40550-017-0056-8>
- National Institute for Occupational Safety and Health. NIOSH Skin Notation (SK) profiles: Dichlorvos. Department of Health and Human Services. Centre for Disease Control and Prevention publication No. 134; 2017.
- Nazam N, Lone MI, Shaikh S, Ahmad W. (2013). Assessment of genotoxic potential of the insecticide Dichlorvos using cytogenetic assay. *Interdiscip Toxicol.*, 6(2):77-82. doi: 10.2478/intox-2013-0014.
- Partap, U.M.A., Partap, T.E.J. and Yonghua, H.E., (2000). Pollination Failure in Apple Crop and Farmers' Management Strategies in Hengduan Mountains, China. In VIII International Symposium on Pollination-Pollination: Integrator of Crops and Native Plant Systems 561 (pp. 225-230).
- Ratnakar, V., Koteswar, Rao, S.R., Sridevi, D. and Vidyasagar, B., (2017). Contact toxicity of certain conventional insecticides to European honeybee, *Apis mellifera* Linnaeus. *International Journal of Current Microbiology and Applied Sciences*, 6(8), pp.3359-3365.
- Regenstrief Institute, Inc. and the Logical Observation Identifiers Names and Codes (LOINC) Committee. Dichlorvos LP18945-3. Available <https://www.findacode.com/loinc/LP18945-3--dichlorvos.html>
- Stephen, D. and Meera, S., (2010). An assessment of carbaryl residues on brinjal crop in an agricultural field in Bikaner, Rajasthan (India). *Asian Journal of Agricultural Sciences*, 2(1), pp. 15-17.
- The Pesticide Manual, 12th ed.; Tomlin, C. D. S., (2000) British Crop Protection Council: Farnham, Surrey, UK, pp. 67-68.
- Zhao, S. X., Zhang, Q. S., Kong, L., Zhang, Y. G., Wang, R. Q., Nan, Y. M., & Kong, L. B. (2015). Dichlorvos induced autoimmune hepatitis: a case report and review of literature. *Hepatitis monthly*, 15(4).

## Carbaryl

Carbaryl is an obsolete carbamate insecticide. In Kenya it is registered in only **2 products** to control aphids on citrus, grapes and tomatoes.

General aspects	
Registered products containing Carbaryl	Hycarb 85 WP Sevin 85 S
Manufacturing companies	Haili Guixi Chemical Pesticide Co. Ltd, China NovaSource / Tessenderlo Kerley Inc. Phoenix, Arizona U.S.A.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Citrus, Grapes, Tomatoes
Pest	Aphids
Alternatives*	Fortune, Magneto, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Oxymatrine, pyrethroids Spirotetramat, Acrinathrin, Pyriproxifen, Flubendiamide
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021  
 \*\* Pesticide Properties Database: University of Hertfordshire, 2021  
 Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Acute effects are due to cholinergic overstimulation and may include respiratory depression, bronchospasms, increased bronchial secretions, pulmonary edema, blurred vision, miosis, headache, tremors, muscle fasciculation, convulsions, mental confusion, coma, death and sludge syndrome. Neurophysiological and neuro behavioral effects have been recorded in high dose exposure to carbaryl (Harp *et al.*, 2005).

### Neurotoxicity

Chronic occupational exposure of humans to carbaryl has been observed to cause cholinesterase inhibition. Male mice had an increased number of blood vessel tumors at all dose levels (NCBI, 2021).

### Carcinogenicity

Carbaryl exposure has been associated with non-Hodgkin's lymphoma, cutaneous melanoma and prostate cancer (Wexler *et al.*, 2014).

### Reproductive/developmental toxicity

Reduced fertility and litter size and increased mortality in offspring have been observed in rats exposed to carbaryl in their diet over three generations (EPA, 2000).

### Endocrine disruption

Carbaryl has a weak estrogen effect (Cocco, 2002). It causes reduction of testosterone and increase in Luteinizing hormone and the follicle stimulating hormone (Fattahi *et al.*, 2012). It causes sperm aneuploidy and sperm DNA fragmentation and it also causes neurodevelopmental or childhood behavioral problems (Frazier, 2008). Carbaryl causes sperm toxicity (reduces sperm motility and concentration) and DNA damage (Wexler *et al.*, 2014). Carbaryl causes reduction of testosterone and thus reducing spermatogenesis and causing infertility in men (Fattahi *et al.*, 2012).

## Food safety issues

The insecticide has potential for acute and chronic dietary exposure to carbaryl residues in food commodities (Australian Pesticides & Veterinary Medicines Authority, 2006).

Carbaryl residues above MRL have been detected in tomatoes from hippo, kingfisher and Harnekop green house farms in Thika and Naivasha, in Kenya (Kinyunzu, 2015).

Carbaryl has also been detected in honey from Seychelles (Muli *et al.*, 2018)

However, carbaryl was below instrumental detection limit for vegetable (kales, spinach, French beans) samples from peri-urban areas of Nairobi (Omwenga *et al.*, 2020)

## Environmental toxicity and environmental behavior of concern

Carbaryl has a low aqueous solubility and is volatile (Lewis *et al.*, 2016). It is not persistent in either soil or water systems (Harp *et al.*, 2005).

**High bee toxicity:** There is some evidence of toxicity to bees more widely, including leaf-cutter bees (Megachilidae) (Peach *et al.*, 1994; Kasina *et al.*, 2009; Gous *et al.*, 2021). This group of bees are very important pollinators of legumes in Kenya, including of cowpeas, pigeon peas and the traditional vegetable 'mitoo' in Western Kenya.

**Medium aquatic toxicity:** It is moderately to highly toxic to fish and highly toxic to shrimp, waterfleas, and stoneflies (EFSA, 2006). The main breakdown product of carbaryl is also highly toxic to some fish.

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:


- High reproductive toxicity
- High bee toxicity
- High aquatic toxicity
- Metabolite is toxic to aquatic systems

## References

- Cocco, Pierluigi., (2002). On the Rumors about the Silent Spring . Review of the Scientific Evidence Linking Occupational and Environmental Pesticide Exposure to Endocrine Disruption Health Effects. *Cad. Saúde Pública*, Rio de Janeiro 18(2): 379–402.
- EFSA (European Food Safety Authority), (2006). Peer Review Report to the conclusion regarding the peer review of the pesticide risk assessment of the active substance Carbaryl.
- U.S. Environmental Protection Agency. (2000). Fact sheet: Carbaryl. <https://www.epa.gov/sites/default/files/2016-09/documents/carbaryl.pdf>
- Fattahi, E., Jorsaraei, S. and Gardaneh, M. (2012). The effect of Carbaryl on the pituitary-gonad axis in male rats. *Iranian journal of reproductive medicine*. 10. 419-24.
- Linda M. Frazier MD, MPH (2007) Reproductive Disorders Associated with Pesticide Exposure, *Journal of Agro-medicine*, 12:1, 27-37, DOI: 10.1300/J096v12n01\_04
- Gous, A., Eardley, C.D., Johnson, S.D., Swanevelder, D.Z. and Willows-Munro, S., (2021). Floral hosts of leaf-cutter bees (Megachilidae) in a biodiversity hotspot revealed by pollen DNA metabarcoding of historic specimens. *Plos one*, 16(1), p.e0244973.
- Harp, R.P (2005). Carbaryl. *Encyclopedia of Toxicology*: <https://doi.org/10.1016/B0-12-369400-0/00180-0>
- Kasina, M., Hagen, M., Kraeme, M., Nderitu, J., Martius, C. and Wittmann, D., (2009). Bee pollination enhances crop yield and fruit quality in Kakamega, Western Kenya.
- Kinyunzu J. (2015). Residues concentrations of carbaryl pesticide in soil and tomatoes from hippo, kingfisher and harnekop green house farms in Thika and Naivasha, Kenya.
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A., (2016) An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- Muli, E., Kilonzo, J., Dogley, N. *et al.* (2018). Detection of Pesticide Residues in Selected Bee Products of Honeybees (*Apis mellifera* L.) Colonies in a Preliminary Study from Seychelles Archipelago. *Bull Environ Contam Toxicol* 101, 451–457. <https://doi.org/10.1007/s00128-018-2423-4>
- National Center for Biotechnology Information (2021). PubChem Compound Summary for CID 6129, Carbaryl. Retrieved September 13, 2021 from <https://pubchem.ncbi.nlm.nih.gov/compound/Carbaryl>. <https://doi.org/10.1007/s00128-018-2423-4>
- Omwenga, I., Kanja, L., Zomer, P., Louisse, J., Rietjens, I. M. C. M., & Mol, H. (2020). Organophosphate and carbamate pesticide residues and accompanying risks in commonly consumed vegetables in Kenya. *Food Additives & Contaminants*: <https://doi.org/10.1080/19393210.2020.1861661>
- Peach, M.L., Alston, D.G. and Tepedino, V.J., (1994). Bees and bran bait: Is carbaryl bran bait lethal to alfalfa leaf cutting bee (Hymenoptera: Megachilidae) adults or larvae? *Journal of economic entomology*, 87(2), pp.311-317.
- Wexler, 2014. *Encyclopedia of Toxicology*. Elsevier ISBN 978-0-12-386455-0

## Carbofuran

Carbofuran is an N-Methyl-carbamate insecticide. Carbofuran is banned in the United States of America and Europe. Carbofuran should have been officially banned in Kenya in the year 2019. However, the U.S. manufacturer, FMC Corporation, who has since lost the patent, only withdrew it from the shelves. As a result carbofuran is still available and produced by other companies and has been substituted by carbosulfan, which is as toxic as carbofuran.

General aspects	
Registered products containing Carbofuran	Furaha 20 SC (until 2019)
Manufacturing companies	Shandong Huayang International Co. (K) Ltd., China.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Banned in Kenya
Pest	Banned in Kenya
Alternatives*	Not applicable as banned
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021  
 \*\* Pesticide Properties Database: University of Hertfordshire, 2021  
 Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

It is very toxic by ingestion and inhalation (EFSA, 2009). Exposure to carbofuran may lead to a cholinergic crisis with signs such as salivation, lacrimation, urinary incontinence, diarrhoea, gastrointestinal cramping, and emesis



(sludge syndrome). Seizures, coma, diaphoresis, muscle weakness and fasciculation, bradycardia, and tachycardia may occur. Death may result from severe bronchoconstriction and respiratory paralysis. Carbofuran is unlikely a carcinogen to humans (Song, 2014).

### Neurotoxicity

The cholinesterase inhibition can overstimulate the nervous system, causing hypersalivation, nausea, dizziness, confusion, and at very high exposures (e.g. accidents or major spills), respiratory paralysis, and death.

### Reproductive toxicity

Carbofuran and/or its major metabolites can cross the placental barrier and produce serious effects on the maternal-placental-foetal unit. Carbofuran's toxicity can be potentiated by simultaneous exposure with other cholinesterase inhibitors. Chronic toxicity testing on laboratory rats showed reduced offspring survival and body weight reductions EPA (2016). When exposed in utero or during lactation, a decrease in sperm motility and sperm count along with an increase in percent abnormal sperm was observed in rats at 0.4 mg/kg dose level (Pant *et al.*, 1997).

In one study, the exposure of rats to sublethal amounts of carbofuran decreased testosterone by 88%. At the same time, the levels of progesterone, cortisol, and estradiol were significantly increased (1279%, 202%, and 150%, respectively) (Goad, *et al.*, 2004).

### Endocrine toxicity

Carbofuran is an endocrine disruptor and a probable reproduction/development intoxicant (IUPAC, 2021). At low-level exposures, carbofuran may cause transient alterations in the concentration of hormones. These alterations may consequently lead to serious reproductive problems following repeated exposure (Lau, *et al.*, 2007). Additionally, carbofuran increases progesterone, cortisol and estradiol levels and decreases testosterone (Goad *et al.* 2004).

### Others

Carbofuran exposure is associated with an elevated risk of developing diabetes (Popovska-Gorevski, 2017).

## Food safety issues

Due to its widespread use in agriculture, contamination of food, water, and air has become imminent, and consequently, adverse health effects are inevitable in humans, animals, wildlife, and fish (Ramesh, 2009).

### Examples:

Carbofuran concentrations exceeding stipulated MRLs have been detected in tomato, okra and brinjals from Bangladesh (Hossain *et al.*, 2015). Carbofuran has also been detected in honey in France (Lambert *et al.*, 2013). High carbofuran levels have also been reported in potatoes from Egypt (Kadah *et al.*, 2018), in dates from Saudi Arabia (Abdalla *et al.*, 2018) and in citrus from China (Li *et al.*, 2020).

## Environmental toxicity and environmental behavior of concern

Because of its high solubility in water and long half-life in soil, it has a high potential for groundwater contamination as it is mobile in soil. It is not persistent in soil but may persist in water under some conditions. It is extremely lethal to mammals, birds, fish and wildlife due to its anticholinesterase activity, which inhibits acetyl-cholinesterase and butyrylcholinesterase activity (Mishra, *et al.*, 2020).

**Misuse of carbofuran:** There is widespread evidence of the misuse of this pesticide in Kenya previously for the poisoning of wildlife. Farmers in Kenya used carbofuran to kill lions and other animals (Rio *et al.*, 2012; Terzić *et al.*, 2010; Otieno *et al.*, 2010). It has been used to poison household pets in a number of high-profile cases throughout the world. (Vušović, 2011, Grobler, 2019).

**High bee toxicity:** It is highly toxic to honeybees. There is also evidence that it can impact flowering plant cycles and, therefore, pollinators. Carbofuran demonstrated an unacceptable danger to a terrestrial, small wild animals, and bee mortality (Secretariat of the Rotterdam Convention - UNEP, 2021). Carbofuran was found to be highly toxic to bees, having an acute LD50 of 0.16 g/bee when exposed.

**High aquatic toxicity:** Carbofuran is highly toxic to freshwater and estuarine/marine fish acutely. The available chronic tests showed larval survival as the most sensitive endpoint for freshwater fish and embryo hatching as the most sensitive endpoint for estuarine/marine fish (EPA, 2016). In addition, chronic tests showed reproductive effects (EPA, 2016).

**High bird toxicity:** Carbofuran is highly toxic to birds on an acute basis and highly toxic on a sub-acute basis. A chronic effect level could not be established due to the fact that all concentrations tested caused mortality in the test subjects (EPA, 2016; Song, 2014; Munir *et al.*, 2011).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient should **be banned**:

- Toxicity to non-target organisms and to its potential to pollute soils and ground water (reason for ban in Europe and U.S.)
- High toxicity to bees, aquatic life, birds
- Non-compliance with recommended measures for risk mitigation by untrained farmers and lack of regulations that require the use of protective gear during pesticide handling
- Misuse in killing wildlife
- It is an endocrine disruptor and a probable reproduction/development intoxicant

## References

- Abdallah, O. I., Alamer, S. S., & Alrasheed, A. M., (2018). Monitoring pesticide residues in dates marketed in Al-Qassim, Saudi Arabia using a QuEChERS methodology and liquid chromatography–tandem mass spectrometry. *Biomedical Chromatography*, 32(6).
- Del Rio, Alfonso & Bamberg, John & Centeno-Diaz, Ruth & Salas, Alberto & Roca, William & Tay, David. (2012). Effects of the Pesticide Furadan on Traits Associated with Reproduction in Wild Potato Species. *American Journal of Plant Sciences*. 3. 1608-1612. 10.4236/ajps.2012.311194.
- European Food Safety Authority, (2009). Conclusion on pesticide peer review regarding the risk assessment of the active substance carbofuran. <https://doi.org/10.2903/j.efsa.2009.310r>
- U.S. Environmental Protection Agency. (2016) Carbofuran I.R.E.D. FACTS [https://archive.epa.gov/pesticides/re-registration/web/html/carbofuran\\_ired\\_fs.html](https://archive.epa.gov/pesticides/re-registration/web/html/carbofuran_ired_fs.html)
- Goad, Ryan T., Goad, John T., Atieh, Bassam H., Gupta, Ramesh C., (2004). Carbofuran-induced endocrine disruption in adult male rats. *Toxicology Mechanisms and Methods*, 14(4), 233–9. doi:10.1080/15376520490434476.
- Hossain, M. S., Fakhruddin, A. N. M., Alamgir Zaman Chowdhury, M., Rahman, M. A., Khorshed Alam, M. (2015). Health risk assessment of selected pesticide residues in locally produced vegetables of Bangladesh. *International Food Research Journal*, 22(1), 110-115
- International Union of Pure and Applied Chemistry, (2021). <http://sitem.herts.ac.uk/aeru/iupac/Reports/118.htm>
- Kadah T. M. Said and A. M. Elmarsafy., (2018). Measuring the economic impact and health risk of pesticide residues in potatoes and grapes corps. *Egypt. J. Agric. Research*, 96(3), 1203-1228. DOI: 10.21608/ejar.2018.141160
- Lambert, O., Piroux, M., Puyo, S., Thorin, C., L'Hostis, M. *et al.* (2013). Widespread Occurrence of Chemical Residues in Beehive Matrices from Apiaries Located.
- Lau TK, Chu W, Graham N. Degradation of the endocrine disruptor carbofuran by UV, O<sub>3</sub> and O<sub>3</sub>/UV. *Water Sci Technol*. 2007;55(12):275-80. doi: 10.2166/wst.2007.416.
- Li, Zhixia., Zhang, Yaohai., Zhao, Qiyang., Wang, Chengqiu., Cui, Yongliang., Li, Jing., Chen, Aihua., Liang, Guolu., Jiao, Bining., (2020). Occurrence, temporal variation, quality and safety assessment of pesticide residues on citrus fruits in China. *Chemosphere*, 258, <https://doi.org/10.1016/j.chemosphere.2020.127381>
- Mishra S, Zhang W, Lin Z, Pang S, Huang Y, Bhatt P, Chen S., (2020). Carbofuran toxicity and its microbial degradation in contaminated environments. *Chemosphere*, 259:127419. doi: 10.1016/j.chemosphere.2020.127419.
- Munir *et al.*, (2011). Major Declines in the Abundance of Vultures and Other Scavenging Raptors in and around the Massai Mara Ecosystem. *Kenya Biol. Conserv.* 44(2), 746-752. <https://doi.org/10.1016/j.biocon.2010.10.024>.
- Otieno, P.O., Lalah, J.O., Virani, M., Jondiko, I.O. and Schramm, K.W., (2010). Carbofuran and its toxic metabolites provide forensic evidence for Furadan exposure in vultures (*Gyps africanus*) in Kenya. *Bulletin of environmental contamination and toxicology*, 84(5), pp.536-544.
- Pant, N., Shankar, R., Srivastava, SP., (1997). In utero and lactational exposure of carbofuran to rats: effect on testes and sperm. *Human & Experimental Toxicology*. 16 (5): 267–72. doi:10.1177/096032719701600506.
- Popovska-Gorevski M, Dubocovich ML, Rajnarayanan RV. (2017). Carbamate Insecticides Target Human Melatonin Receptors. *Chem Res Toxicol.*, 30(2). doi: 10.1021/acs.chemrestox.6b00301
- Ramesh C. Gupta (2009) Carbofuran toxicity. *Journal of Toxicology and Environmental Health*, 43:4, 383-418, DOI: 10.1080/15287399409531931
- Xun Song, (2005). Carbofuran. *Encyclopedia of Toxicology* (Second Edition), Elsevier, 2005, Pages 417-418.
- Terzić, S., Milovac, Ž., Miklič, V., Atlagić, J., Dedić, B., Marjanović-Jeromela, A. and Mikić, A., (2010). Influence of insecticide seed treatment on pollinator and harmful insects visit to sunflower. *Selekcija I semenarstvo*, 16(1), pp.17-24.
- Vušović, A., (2011). "Psi u naselju Braće Jerković otrovani pesticidima". Blic (in Serbian).
















## Chlorpyrifos

Chlorpyrifos (CPS) is an organophosphate insecticide and is registered in **25 products**. It is not allowed to be applied on vegetables. It is only registered for control of various insect pests on barley, maize, wheat and pineapples. Despite this, it was the most used pesticides by farmers in Kirinyaga and Murang'a on kale, maize, tomatoes, melon, avocado, sweet potatoes, cabbage, rice and coffee (KOAN, 2020).













General aspects	
Registered products containing Chlorpyrifos	Agropyrifos 48 EC Anaconda 55 EC Antfex 48 EC Betafos 263 EC, Bulldock star EC 262.5 Cobra 75WG Colt 480 EC Cyren 480 EC Dursban 4 EC Epyrifos Gladiator 4TC Glean 75 DF Jawabu 48 EC Mursban 480 Pyriban 480 EC Pyrinex 48 EC Pyrinex quick 256 ZC Ranger 48% EC Reldan 40 EC Robust 48 EC Royalnex CS 25 Spectator Gold 500 EC Sulban 48 EC Tricel 48EC Twigapyrifos 480EC
	Adama Makhteshim Ltd, Israel. AIMCO pesticides Ltd, India Asiatic Agricultural Industries, Singapore. Bayer Crop Science Germany Cheminova Agro AS, Denmark. Dow Agro Sciences Export S.A./ Middle East / East Africa. Dow Agrosciences, France Dow Agrosciences, UK. Du pont De Nemours and Co. Inc, USA / Du Pont De Nemours International S.A Geneva, Switzerland. Excel Crop Care Limited, Mumbai, India Gharda Chemicals Ltd, India Jiangsu Huangma Agrochemical Co. Ltd., China Makhteshim Chemical Works / Crompton Ltd. Makhteshim Chemical Works, Ltd, Israel Ningbo Sunjoy Agroscience Co, China. Sabero Organics, India. Sulphur Mills India. Tagros chemical Pvt Ltd, India Zhejiang Xinnong Chemicals Co. Ltd, China
Manufacturing companies	
HHP	Yes
Withdrawn in Europe	Yes

<b>Crops treated</b>	Barley, Maize, Wheat, Pineapples
<b>Pest</b>	Caterpillars, Termites, Ants, Aphids, Thrips, Whitefly, Bollworms, Antestia bugs, Armyworms, Mosquitoes larvae, Leaf miner, Mealy bugs
<b>Alternatives*</b>	Ozoneem, Achook, Nemroc (Azadirachtin), AMINEM XY16 Liquid Emulsion (Carvacrol 2% w/v), NEMguard® (Polysulphide Formulation) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur Oxymatrine, pyrethroids

**Human Health\*\***

<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  

**Environmental Health\*\***

<b>Bee Toxicity</b>	  
<b>Fish Toxicity</b>	  
<b>Earthworm Toxicity</b>	  
<b>Bird Toxicity</b>	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern**

Chlorpyrifos has been categorized as moderately or very harmful to human health by the WHO Food and Agriculture Organization and the Environmental Protection Agency. In addition, chlorpyrifos is classified as a reproduction toxicant, an acetylcholinesterase inhibitor and a neurotoxicant.

**Neurotoxicity**

Acute cholinergic crisis, intermediate syndrome, and delayed neuropathy are the outcomes (Liu, 2020). In addition, poisoning with chlorpyrifos causes heart damage and myeloneuropathy (Ostwal et al., 2013). It can also induce motor axonal polyneuropathy that is delayed (Verma et al., 2013).

### Reproductive and development toxicity

Pregnant women and children are at high risk (Eskenazi *et al.*, 2007). Low-level of exposure to Chlorpyrifos during childhood, infancy and pregnancy has been linked to conditions such as autism, ADHD, developmental delays and lower I.Q. (Rauh *et al.*, 2011; Rauh *et al.*, 2006; Whyatt *et al.*, 2005). It can cause childhood tremors (Rauh *et al.*, 2015).

Chlorpyrifos is associated with adverse reproductive effects in both men and women. In men, it is associated with sperm DNA fragmentation and thus contributing to male infertility (Zhang *et al.* 2020), while in women, it is related to low birth weight and short gestational age; neurodevelopmental or childhood behavioural problems and altered foetal immune cell function in female rats (Fraizer, 2008).

### Carcinogenicity

Chlorpyrifos has been described as a potential risk factor for breast cancer (Ventura *et al.* 2019). A significant association has been demonstrated between CPS and Hodgkin's lymphoma among males (Chandima *et al.*, 2012). Watts (2012) revealed the existence of lymph hematopoietic cancer, cancer of the brain, lungs and kidneys among workers exposed to CPF. Chlorpyrifos can produce DNA damage through topoisomerase II inhibition (Lu *et al.*, 2015). Epidemiological studies showed a significant association between pesticides exposure and childhood leukaemia, including infant leukaemia (Ntzani *et al.*, 2013; Hernandez and Menendez, 2016).

### Endocrine disruption

Chlorpyrifos acts as an androgen receptor antagonists and thus interfering with the hypothalamic gonadotrophin synthesis pathway responsible for the production of luteinizing hormone and follicle-stimulating hormone steroidogenesis (Alaa-eldin *et al.*, 2016).

## Food safety issues

Chlorpyrifos is the most often found pesticide residue in Kenya, according to Kunyanga *et al.* (2018). Kale and French beans were discovered in a research by Mutai *et al.* (2015) to contain up to 100 µg/kg of chlorpyrifos residues in peri-urban Nairobi. Chlorpyrifos, acephate, omethoate and methamidophos exceeded the Codex and/or E.U. MRLs (Omwenga *et al.*, 2020).

Elgueta *et al.* (2019) found that chlorpyrifos was detected more frequently in lettuce, spinach, and chard. Chlorpyrifos concentrations in spinach, lettuce, cabbage, tomato and onions from Nigeria were reported to exceed the MRLs (Akan *et al.*, 2013).

As a result of the proposed withdrawal from the European market on 18 February 2020, Member States endorsed a proposal by the Commission to lower the MRLs of chlorpyrifos and chlorpyrifos-methyl in food and feed to the lowest level that can be measured by analytical laboratories (European Commission, 2020).

## Environmental toxicity and environmental behavior of concern

Chlorpyrifos has a low aqueous solubility, is quite volatile and is non-mobile. It has a low risk of leaching to groundwater based on its chemical properties but it can be moderately persistent in soil systems (Lewis *et al.*, 2016). It is highly toxic to aquatic species, honey bee and birds (Mehler *et al.*, 2008; Lewis *et al.*, 2016).

**High bee toxicity:** It is highly toxic to many different kinds of insects including pollinators and aquatic insects. It has been shown to be disruptive to bee foraging behaviour, but when risk mitigation practices are used, impacts can be minimised (Urlacher *et al.*, 2016; Cutler *et al.*, 2014). Shown to be very toxic to stingless bees (Leite *et al.*, 2021).

It is **highly toxic to mammals**, is classified as a reproduction toxicant, an acetyl cholinesterase inhibitor and a neurotoxicant. It is also a skin and eye irritant (Mehler *et al.*, 2008; Lewis *et al.*, 2016).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Residue in marketed French beans and kales raising food safety concerns
- Non-compliance with recommended measures for risk mitigation by farmers
- Endocrine disrupting activity and neurotoxicity towards farm workers
- High risk to children resulting to learning difficulties
- High bee and aquatic toxicity

Chlorpyrifos meets the criteria for classification as toxic for reproduction category 1B (regarding developmental toxicity).


















## References

- Akan J. C., Jafiya L., Mohammed Z., Abdulrahman F. I., (2013). Organophosphorus pesticide residues in vegetables and soil samples from alau dam and gongulong agricultural areas, Borno State, Nigeria. *International Journal of Environmental Monitoring and Analysis*, 1(2): 58-64
- Alaa-eldin, Eman Ahmad, Dalia Abdallah El-shafei, and Nehal S Abouhashem., (2016). "Individual and Combined Effect of Chlorpyrifos and Cypermethrin on Reproductive System of Adult Male Albino Rats." *Environmental Science and Pollution Research*. <http://dx.doi.org/10.1007/s11356-016-7912-6>.
- Chandima P. Karunanayake PhD, John J. Spinelli PhD, John R. McLaughlin PhD, James A. Dosman MD, Punam Pahwa PhD & Helen H. McDuffie PhD (2012) Hodgkin Lymphoma and Pesticides Exposure in Men: A Canadian Case-Control Study, *Journal of Agromedicine*, 17:1, 30-39, DOI: 10.1080/1059924X.2012.632726
- Cutler, G.C., Purdy, J., Giesy, J.P. and Solomon, K.R., (2014). Risk to pollinators from the use of chlorpyrifos in the United States. *Ecological Risk Assessment for Chlorpyrifos in Terrestrial and Aquatic Systems in the United States*, pp.219-265.
- Elgueta, S., Fuentes, M., Valenzuela, M., Zhao, G., Liu, S., Lu, H., Correa, A., (2019). Pesticide residues in ready-to-eat leafy vegetables from markets of Santiago, Chile and consumer's risk. *Food Addit Contam Part B*. 12:259–267. doi:10.1080/ 19393210.2019.1625975.
- Eskenazi, B., Marks, A. R., Bradman, A., Harley, K., Barr, D. B., Johnson, C., Jewell, N. P. (2007). Organophosphate pesticide exposure and neurodevelopment in young Mexican American children. *Environmental Health Perspectives*, 115(5), 792–798. <https://doi.org/10.1289/ehp.9828>.
- European Commission, (2005). Review Report for the active substance chlorpyrifos finalised in the Standing Committee on the Food Chain and Animal Health at its meeting on 3 June 2005 in view of the inclusion of chlorpyrifos in Annex I of Directive 91/414/EEC. SANCO/3059/99
- European Commission, 2020. Chlorpyrifos & Chlorpyrifos-methyl. See: [https://ec.europa.eu/food/plants/pesticides/approval-active-substances/renewal-approval/chlorpyrifos-chlorpyrifos-methyl\\_en](https://ec.europa.eu/food/plants/pesticides/approval-active-substances/renewal-approval/chlorpyrifos-chlorpyrifos-methyl_en)
- Hernandez A.F. and Menendez P., (2016). Linking pesticide exposure with pediatric leukemia: potential underlying mechanisms. *International Journal of Molecular Sciences*, 17:461.
- KOAN-Kenyan Organic Agricultural Network, 2020. Pesticide use in Kirinyaga and Murang'a Counties. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf)
- Kunyanga C, Amimo J, Kingori LN, Chemining'wa G. (2018). Consumer risk exposure to chemical and microbial hazards through consumption of fruits and vegetables in Kenya. *Food Sci Qual Manage*. 78.
- Leite, D.T., Sampaio, R.B., Chambó, E.D., Aguiar, C.M.L., de Godoy, M.S. and de Carvalho, C.A.L., (2021). Toxicity of chlorpyrifos, cyflumetofen, and difenoconazole on *Tetragonisca angustula* (Latreille, 1811) under laboratory conditions. *International Journal of Tropical Insect Science*, pp.1-9.
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016) An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- Liu, H. F. *et al.*, (2020). Outcome of patients with chlorpyrifos intoxication. *Hum. Exp. Toxicol*. 39, 1291–1300 <https://doi.org/10.1177/0960327120920911>
- Lu C, Liu X, Liu C, Wang J, Li C, Liu Q, Li Y, Li S, Sun S, Yan J, Shao J., (2015). Chlorpyrifos Induces MLL Translocations Through Caspase 3-Dependent Genomic Instability and Topoisomerase II Inhibition in Human Fetal Liver Hematopoietic Stem Cells. *Toxicol Sci*, 147(2):588-606. doi: 10.1093/toxsci/kfv153.
- Lu, S., Liu, S., Cui, J., Xiaoyi, L., Zhao, C., Fan, L., Yin, S. and Hu, H. (2019). Combination of Patulin and Chlorpyrifos Synergistically Induces Hepatotoxicity via Inhibition of Catalase Activity and Generation of Reactive Oxygen Species. *Journal of Agricultural and Food Chemistry*. 10.1021/acs.jafc.9b04814.

- Mehler, W.T., Schuler, L.J., Lydy, M.J., (2008). Examining the joint toxicity of chlorpyrifos and atrazine in the aquatic species: *Lepomis macrochirus*, *Pimephales promelas* and *Chironomus tentans*. *Environ. Pollut.* 152, 217224.
- Mutai, C., Inonda, R., Njage, E., Ngeranwa, J., (2015). Determination of pesticide residues in locally consumed vegetables in Kenya. *Afr J Pharmacol Ther.* 4:1–6.
- Ntzani E.E., Chondrogiorgi M., Ntritsos G., Evangelou E. and Tzoulaki I., (2013). Literature review on epidemiological studies linking exposure to pesticides and health effects. *EFSA Supporting Publication* 10(10): EN-497, pp. 159. <https://doi.org/10.2903/sp.efsa.2013.en-497>
- Omwenga, I., Kanja, L., Zomer, P., Louisse, J., Rietjens, IMCM., Mol, H., (2021) Organophosphate and carbamate pesticide residues and accompanying risks in commonly consumed vegetables in Kenya. *Food Addit Contam Part B Surveill.* (1):48-58. doi: 10.1080/19393210.2020.1861661.
- Ostwal, P., Dabadghao, VS., Sharma, SK., Dhakane, AB., (2013). Chlorpyrifos toxicity causing delayed myeloneuropathy. *J Indian Acad Neurol.* 16(4):736 doi: 10.4103/0972-2327.120443
- Rauh, V. A., Garfinkel, R., Perera, F. P., Andrews, H. F., Hoepner, L., Barr, D. B., ... Whyatt, R. W. (2006). Impact of prenatal chlorpyrifos exposure on neurodevelopment in the first 3 years of life among inner-city children. *Pediatrics*, 118(6). <https://doi.org/10.1542/peds.2006-0338>.
- Rauh, V., Arunajadai, S., Horton, M., Perera, F., Hoepner, L., Barr, D. B., & Whyatt, R. (2011). Seven-year neurodevelopmental scores and prenatal exposure to chlorpyrifos, a common agricultural pesticide. *Environmental Health Perspectives*, 119(8), 1196–1201. <https://doi.org/10.1289/ehp.1003160>
- Rauh, Virginia A. *et al.* (2015). Prenatal Exposure to the Organophosphate Pesticide Chlorpyrifos and Childhood Tremor. *NeuroToxicology* 51: 80– 86. <http://dx.doi.org/10.1016/j.neuro.2015.09.004>.
- Ventura, C. & Zappia, Carlos & Lasagna, Michela & Pavicic, W. & Richard, S. & Bolzan, A.D. & Monczor, Federico & Núñez, Mariel & Cocca, Claudia. (2018). Effects of the pesticide chlorpyrifos on breast cancer disease. Implication of epigenetic mechanisms. *The Journal of Steroid Biochemistry and Molecular Biology*. 186. 10.1016/j.jsbmb.2018.09.021.
- Verma, Archana & Kumar, Alok. (2012). Delayed Polyneuropathy as A Rare Manifestation of Chlorpyrifos Poisoning; A case Report. *International Journal of Scientific Research*. 2. 322-323. 10.15373/22778179/MAR2013/99.
- Whyatt, R. M., Camann, D., Perera, F. P., Rauh, V. A., Tang, D., Kinney, P. L., Barr, D. B. (2005). Biomarkers in assessing residential insecticide exposures during pregnancy and effects on fetal growth. *In Toxicology and Applied Pharmacology*, 206, 246–254. <https://doi.org/10.1016/j.taap.2004.11.027>.
- Zhang, Xuelian *et al.*, (2020). Chlorpyrifos Inhibits Sperm Maturation and Induces a Decrease in Mouse Male Fertility. *Environmental Research*, 188: 1–39. <https://doi.org/10.1016/j.envres.2020.109785>

## Deltamethrin

Deltamethrin is a pyrethroid insecticide and veterinary treatment that is approved for use in the EU, Australia and the US. In Kenya, it is registered in **10 products** to control a wide range of pests on a wide range of crops.

General aspects	
Registered products containing Deltamethrin	Decis forte EC Dross 100 EC Atom 2.5EC Decis 2.5 EC Farm X 2.5EC Katrín EC Keshet 2.5 EC K-Obiol DP2 Zerofly storage sack Decis 0.5 ULV
Manufacturing companies	Bayer Crop Science. CongTy TNHH Alfa Vietnam Sulphur Mills, India. Tagros Chemicals, Ltd., India. Adama Makhteshim Ltd, Israel Sichuan Saiwei Biological Engineering Co., Ltd., China
HHP	Yes
Withdrawn in Europe	No
Crops treated	French Beans, Barley, Wheat, Maize, Citrus, Onions, Tomatoes, Cabbages, Peas, Broccoli, Cucumber, Pepper
Pest	Aphids, Thrips, Bollworms, Whiteflies, Weevils, Red flour beetle, Grain borer, Mealy bugs, Caterpillar, Spider mites, Diamond black moth
Alternatives*	Ozoneem, Achook, Nemroc (Azadirachtin), AMINEM XY16 Liquid Emulsion (Carvacrol 2% w/v), NEMguard® (Polysulphide Formulation)  Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur  Oxymatrine, pyrethroids
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  

**Environmental Health\*\*****Bee Toxicity****Fish Toxicity****Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern**

Deltamethrin exposure to humans affects the nervous, reproductive, neuronal, skeletal system and also induces oxidative stress (Del Prado-Lu, 2015; Lidova *et al.*, 2016; WHO, 2016). Acute exposure symptoms include headaches, lacrimation, abdominal pain, nausea, diarrhea, vomiting, apathy, weakness, ataxia, limb spasms, convulsions, allergic reactions, hypersensitivity to sound and touch, anaphylactic shock and facial edema (Kumar *et al.*, 2011). Exposure to the skin may cause paresthesia, tingling, itching, burning and numbness of the skin (Khalatbary *et al.*, 2015).

**Neurotoxicity**

Deltamethrin administered orally or through the skin may accumulate in brain neurons (Viel *et al.*, 2015) it acts on the neuronal dopamine transporter, which may contribute to Parkinson's disease.

**Reproductive and development toxicity**

Deltamethrin-exposed pregnancy may result in changes in fetal central nervous system (Viel *et al.*, 2015). Children were characterized by sleep disorders, impaired memory, poorer verbal abilities and decreased intelligence scores.

**Food safety issues**

Deltamethrin has been reported in Chinese kales sampled from markets in Thailand (Wanwimolruk *et al.*, 2015) and in greenhouse-cultivated tomatoes from Turkey (Hepsağ and Kizildeniz, 2021). Deltamethrin has also been reported in fresh fruits and vegetables including strawberry, watermelon, apple, grapes, tomato, bell pepper, eggplant, cucumber, zucchini, cabbage, carrot and potato from Kuwait with levels exceeding MRLs in several samples (Jallow *et al.*, 2017). Since deltamethrin is a lipophilic compound, with high values of octanol-water partition coefficient (log KOW), it tends to accumulate easily in fat tissues. (Albaseer, 2010)

**Environmental toxicity and environmental behavior of concern**

Deltamethrin is persistent in soils with high organic matter and high clay (U.S. Department of Health and Human Services, 2009). Due to its strong tendency to bind to soil organic matter, it has low potential to leach into groundwater (Lewis *et al.*, 2016). It has a low aqueous solubility, is semi-volatile and has a low potential to leach to groundwater.

**Bee toxicity:** Deltamethrin is shown to be toxic and disruptive to both honeybees and other wild bee species (Del Sarto *et al.*, 2014; Scott-Dupree *et al.*, 2009; Giordano *et al.*, 2020). It is considered to be intermediate in toxicity to wild bees in studies of canola. Impacts on bees and butterflies can be minimised with focused, clear localised applications.

**Aquatic toxicity:** Deltamethrin is extremely harmful to fish (Shikha *et al.*, 2017). Loss of schooling behavior,

swimming towards the water's surface, hyperactivity, convulsions, loss of buoyancy, increased cough rate, increased gill mucus secretions, flaring of the gill arches, head shaking, and listlessness are all symptoms of poisoning in fish (Angahar, 2017; Moraes *et al.* 2013; Souza *et al.* 2020). Inhibited acetylcholinesterase activity in brain, muscle, and gills are the reason for the symptoms.

**Bird toxicity:** It is relatively non-toxic to birds

**Toxicity to other organisms:** Death of insects seems to be due to irreversible damage to the nervous system occurring when poisoning lasts more than a few hours (Timothy, 2012)

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced.

The proposed withdrawal in Kenya should be based on:

- Its negative effects on the nervous system
- Endocrine disrupting activities
- High bee toxicity and other beneficial insects
- Insufficient toxicological data for metabolite

## References

- Albaseer, Saeed & Rao, Ramiseti & Swamy, Yerramsetti & Khagga, Mukkanti. (2010). An Overview of Sample Preparation and Extraction of Synthetic Pyrethroids from Water, Sediment and Soil. *Journal of chromatography. A*. 1217. 5537-54. 10.1016/j.chroma.2010.06.058
- Angahar LT. Investigations of acute toxicity and neurotoxin effects of aqueous extracted pyrethroid (deltamethrin) from insecticide treated mosquito net on clarias gariepinus and heterobranchus bidorsalis. *MOJ Biol Med*. 2017; 1(4):98–101. DOI: 10.15406/mojbm.2017.01.00020
- Saeed S. Albaseer, K. Mukkanti, R. Nageswara Rao, Y.V. Swamy, (2011). Analytical artifacts, sample handling and preservation methods of environmental samples of synthetic pyrethroids. *Trends in Analytical Chemistry*, 30(11), 1771-1780, <https://doi.org/10.1016/j.trac.2011.05.010>.
- Del Prado-Lu, J.L. (2015). Insecticide residues in soil, water, and eggplant fruits and farmers' health effects due to exposure to pesticides. *Environ. Health Prev. Med.*, 20, 53–62.
- Del Sarto, M.C.L., Oliveira, E.E., Guedes, R.N.C. and Campos, L.A.O., 2014. Differential insecticide susceptibility of the Neotropical stingless bee *Melipona quadrifasciata* and the honey bee *Apis mellifera*. *Apidologie*, 45(5), pp.626-636.
- Giordano, B.V., McGregor, B.L., Runkel IV, A.E. and Burkett-Cadena, N.D., 2020. Distance Diminishes the Effect of Deltamethrin Exposure on the Monarch Butterfly, *Danaus plexippus*. *Journal of the American Mosquito Control Association*, 36(3), pp.181-188.
- Hepsağ, F. and Kizildeniz, T. (2021). Pesticide residues and health risk appraisal of tomato cultivated in greenhouse from the Mediterranean region of Turkey. *Environ Sci Pollut Res* 28, 22551–22562. <https://doi.org/10.1007/s11356-020-12232-7>
- Jallow MFA, Awadh DG, Albaho MS, Devi VY, Ahmad N. (2017). Monitoring of Pesticide Residues in Commonly Used Fruits and Vegetables in Kuwait. *Int J Environ Res Public Health*, 14(8):833. doi: 10.3390/ijerph14080833.
- Khalatbary, A.; Ghaffari, E.; Iranian, B. (2015). Protective role of oleuropein against acute deltamethrin-induced neurotoxicity in rat brain. *Iran. Biomed. J.*, 19, 247–253.
- Kumar, S.; Thomas, A.; Pillai, M. (2011). Deltamethrin: Promising mosquito control agent against adult stage of *Aedes aegypti* L. *Asian Pac. J. Trop. Med.*, 4, 430–435.
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016). An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- Lidova, J.; Stara, A.; Kouba, A.; Velisek, J. The effects of cypermethrin on oxidative stress and antioxidant biomarkers in marbled crayfish (*Procambarus fallax f. virginalis*). *Neuro Endocrinol. Lett.* 2016, 37 (Suppl. 1), 53–59.
- Moraes, F.D.; Venturini, F.P.; Cortella, L.R.X.; Rossi, P.A.; Moraes, G. 2013. Acute toxicity of pyrethroid-based insecticides in the Neotropical freshwater fish *Brycon amazonicus*. *Ecotoxicology and Environmental Contamination*, 8: 59-64.
- Scott-Dupree, C.D., Conroy, L. and Harris, C.R., 2009. Impact of currently used or potentially useful insecticides for canola agroecosystems on *Bombus impatiens* (Hymenoptera: Apidae), *Megachile rotundata* (Hymenoptera: Megachilidae), and *Osmia lignaria* (Hymenoptera: Megachilidae). *Journal of economic entomology*, 102(1), pp.177-182.
- Shika, S., Rishikesh, T., Ravi, P. (2018). Evaluation of acute toxicity of triazophos and deltamethrin and their inhibitory effect on AChE activity in *Channa punctatus*. *Toxicology Reports*. 5. 10.1016/j.toxrep.2017.12.006.
- Singh, S.; Tiwari, R.K.; Pandey, R.S. Evaluation of acute toxicity of triazophos and deltamethrin and their inhibitory effect on AChE activity in *Channa punctatus*. *Toxicol. Rep.*, 5, 85–89.



Souza, T.C.; Silva, S.L.R.; Marcon, J.L.; Waichman, A.V. 2020. Acute toxicity of deltamethrin to Amazonian freshwater fish. *Toxicology Environmental Health Sciences*, 12: 149-155.

Timothy CM. Mammalian Toxicology of Insecticides. Royal Society of Chemistry, Issue 12 of Issues in Toxicology 2012, 490.

Toxicological Profile for Pyrethrins and Pyrethroids; U.S. Department of Health and Human Services, Agency for Toxic Substances and Disease Registry. <http://atsdr.cdc.gov/toxprofiles/tp155.html> (accessed Jan 2009), updated Apr 2004.

Viel, J.-F., Warembourg, C., Maner-Idrissi, G., Lacroix, A. & Limon, G., Rouget, F. & Monfort, C., Durand, G., Cordier, S. and Chevrier, C. (2015). Pyrethroid insecticide exposure and cognitive developmental disabilities in children: The PELAGIE mother-child cohort. *Environment International*. 82. 10.1016/j.envint.2015.05.009.




























Wanwimolruk, S., Kanchanamayoon, O., Phopin, K., Prachayasittikul, V. (2015). Food safety in Thailand 2: Pesticide residues found in Chinese kale (*Brassica oleracea*), a commonly consumed vegetable in Asian countries. *Science of the Total Environment*, 532, 447–455.

World Health Organization (WHO). Pesticide Evaluation Scheme, Vector Ecology and Management; World Health Organization: Geneva, Switzerland, 2016.



## Gamma-Cyhalothrin

Gamma-Cyhalothrin is a broad-spectrum pyrethroid insecticide and is registered in **one product** to control sucking insects on French beans. However, Lambda-Cyhalothrin is registered in many more products and is regularly used by farmers (KOAN, 2020).

General aspects	
Registered products containing Gamma-Cyhalothrin	Vantex 60 CS
Manufacturing companies	Cheminova Agro- A/S, Denmark
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	French beans
Pest	Thrips, Aphids, Whiteflies, Caterpillars
Alternatives*	Ozoneem, Achook, Nemroc (Azadirachtin), AMINEM XY16 Liquid Emulsion (Carvacrol 2% w/v), NEMguard® (Polysulphide Formulation) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur Oxymatrine, pyrethroids
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Gamma-Cyhalothrin is highly toxic after inhalation, acutely toxic after ingestion and moderately toxic upon contact with skin. Clinical signs after exposure include salivation, incoordination, postural, abnormalities, hyper excitability, and tremors (EFSA, 2014). Gamma-Cyhalothrin is acutely poisonous when consumed, toxic when inhaled (EFSA Journal, 2014; Stewart, J, 2018).

### Neurotoxicity

As a pyrethroid, it is considered to be a neurotoxicant PPDB (2021).

### Hepatotoxicity

Possible liver toxicant PPDB (2021). Hepatic damage is likely due to increased oxidative stress and inflammation under the condition of acute and subchronic exposure to lambda-cyhalothrin and that LTC metabolites (CFMP and 3-PBA) could be used as potential biomarker in human biomonitoring studies (Aouey, *et al.*, 2017).

## Food safety issues

Cyhalothrin residues have been reported in various foodstuffs including wheat and bayberry from China (Tao *et al.*, 2021; Yang *et al.*, 2017), vegetables grown in several sub-Saharan African countries such as Benin, Cameroon and Mali (Luc *et al.*, 2019).

## Environmental toxicity and environmental behavior of concern

It has a low aqueous solubility, is volatile and, based on its chemical properties, would not be expected to leach to groundwater. It is non-persistent in soil systems and would not normally persist in aqueous systems.

It has a high mammalian toxicity and there is some concern regarding its potential to bioaccumulate.

**Bee toxicity:** There is limited data on the effects of this compound on bees. Evidence is mainly drawn from other general studies on pesticides and pollinators. Notably, even low levels of exposure in certain insects can lead to the development of wide spectrum insecticide resistance, which impacts groups like houseflies or disease vectors (Khan, 2020).

**Aquatic toxicity:** High risk to aquatic organisms (EFSA Journal, 2014; Vieira, 2018). Some evidence of toxicity to aquatic invertebrates (van Wijngaarden *et al.*, 2009).

**Bird toxicity:** Low acute, but long-term risk to birds and wild mammals (EFSA Journal, 2014)

Gamma-Cyhalothrin indicates a high long-term risk to wild mammals (EFSA Journal, 2014). It is highly toxic to a reptile species (*G. occidentalis*), causing 76% mortality (EFSA Journal, 2014)

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced.

Proposed withdrawal in Kenya should be based on:




























- Insufficient toxicological data for mammals and the breakdown product (metabolite) of Gamma-Cyhalothrin
- High toxicity towards bees and aquatic life

## References

- Aouey B, Derbali M, Chtourou Y, Bouchard M, Khabir A, Fetoui H. 2017. *Pyrethroid insecticide lambda-cyhalothrin and its metabolites induce liver injury through the activation of oxidative stress and proinflammatory gene expression in rats following acute and subchronic exposure. Environ Sci Pollut Res Int*;24(6):5841-5856. doi: 10.1007/s11356-016-8323-4. PMID: 28058584.
- European Food Safety Authority, (2014). *Conclusion on the peer review of the pesticide risk assessment of the active substance gamma-cyhalothrin*. EFSA Journal;12 (2):3560.
- EFSA, (2014). *Peer review of the pesticide risk assessment of the active substance gamma-cyhalothrin*. <https://efsa.onlinelibrary.wiley.com/doi/pdf/10.2903/j.efsa.3560>
- Khan, H.A.A., (2020). *Side effects of insecticidal usage in rice farming system on the non-target house fly Musca domestica in Punjab, Pakistan*. Chemosphere, 241, p.125056.
- KOAN-Kenyan Organic Agricultural Network, (2020). *Pesticide use in Kirinyaga and Murang'a Counties*. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf)
- Luc I., Renwei H., Pereira L. et al. (2019). *Food Chemistry: X, (2). Sub-Saharan Africa total diet study in Benin, Cameroon, Mali and Nigeria: Pesticides occurrence in foods*. <https://doi.org/10.1016/j.fochx.2019.100034>
- PPDB (2021): *Pesticide Properties DataBase, University of Hertfordshire* <http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/369.htm>
- Stewart, J, (2018). *Draft Human Health and Ecological Risk Assessment for Lambdacyhalothrin in Exotic Fruit Fly Applications, USDA, United States Department of Agriculture Marketing and Regulatory Programs*.
- Tao Y., Chunhong J., Junjie J. et al. (2021). *Food Chemistry, 350. Occurrence and dietary risk assessment of 37 pesticides in wheat fields in the suburbs of Beijing, China*. <https://doi.org/10.1016/j.food-chem.2021.129245>
- van Wijngaarden, R.P., Barber, I. and Brock, T.C., (2009). *Ecotoxicology. Effects of the pyrethroid insecticide gamma-cyhalothrin on aquatic invertebrates in laboratory and outdoor microcosm tests*.18 (2), pp.211-224.
- Vieira, C.E.D.; dos Reis Martinez, C.B. Chemosphere. *The pyrethroid  $\lambda$ -cyhalothrin induces biochemical, genotoxic, and physiological alterations in the teleost Prochilodus lineatus*. 210, 958–967
- Yang, Gui-ling; Wang, Wen; Liang, Sen-miao; Yu, Yi-jun; Zhao, Hui-yu; Wang, Qiang; Qian, Yong-zhong (2017). *Pesticide residues in bayberry (Myrica rubra) and probabilistic risk assessment for consumers in Zhejiang, China. Journal of Integrative Agriculture, 16(9), 2101–2109*. [https://doi.org/10.1016/S2095-3119\(16\)61600-3](https://doi.org/10.1016/S2095-3119(16)61600-3)

## Permethrin

Permethrin is a contact insecticide. It is registered in **3 products** to control maize stalkborer and other insects in stored grains.

General aspects	
Registered products containing Permethrin	Ambush 25 DC (formerly Permethrin 25WP) Deraphon P 1% Dragnet FT
Manufacturing companies	FMC Corporation, USA. Syngenta UK Ltd. United Phosphorous Ltd., India.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Maize
Pest	Large grain borer, Lesser grain borer, Angoumois grain moth, Maize weevils, Aphids
Alternatives*	Magneto, Nimbecidine, Trilogy (Azadirachtin)
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021  
 \*\* Pesticide Properties Database: University of Hertfordshire, 2021  
 Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Permethrin can cause a variety of toxicities in humans such as neurotoxicity, reproductive toxicity, immune toxicity, genotoxicity, hepatotoxicity and cardiotoxicity (Carlioni *et al.*, 2012, 2013; Falcioni *et al.*, 2010; Nasuti *et al.*, 2014; Issam *et al.*, 2011; Gabbianelli *et al.*, 2009; Turkez and Aydin, 2012, 2013; Turkez and Togar, 2011; Gabbianelli *et al.*, 2013; Vadhana *et al.*, 2011, 2013). It is also a skin and eye irritant (Lewis *et al.*, 2016). Some of the symptoms associated with excessive exposure of permethrin include epidermal lesions, sore throat, nausea, vomiting, abdominal pain, gastrointestinal mucosal irritation, salivation, respiratory distress and headaches (Toynton, 2009; Skolarczyk *et al.*, 2017). The use of permethrin in household is often associated with allergies and asthma, especially in children. Long-term exposure to children can result to increased aggressive behaviors (Oulhote *et al.*, 2013).

Permethrin is categorized as a carcinogen, an endocrine disruptor, or a neurotoxin (Lewis *et al.*, 2016).

### Neurotoxicity

Permethrin causes neurotoxicity and it mimics organophosphate poisoning (Drago *et al.*, 2014). The neurological effect of permethrin is as result of its action on the Gamma Amino Butyric Acid (GABA) receptors and alteration of chloride current, thus resulting in neurological excitation (Drago *et al.*, 2014). It poses little Parkinsonian hazard to humans, including when impregnated into clothing for control of biting flies (Jinghong & Jeffrey, 2007).

### Hepatotoxicity disrupting activity

Long-term exposure of children to permethrin caused an increase in the amount of permethrin metabolites in the urine, as well as behavioral changes, in particular an increase of aggressive behaviors has been observed (Outhlote *et al.*, 2013).

### Carcinogenicity

US EPA has reclassified it as likely to be carcinogenic to humans by ingestion, based on mouse studies where lung and liver tumors were observed (Corcellas *et al.*, 2014). Permethrin causes childhood leukemia and it causes genotoxicity and cytotoxicity in humans (Ramos-Chavez *et al.*, 2015).

### Immunotoxicity

Induced immune disorders (Skolarczyk, 2017), it alters the immune pathway and causes an autoimmune reaction in the body (Joshi *et al.*, 2019).

### Reproductive toxicity

Metabolites of permethrin were detected in breast milk from women (Corcellas *et al.*, 2014).

### Nephrotoxicity

Permethrin metabolites present in the urine of children aged 6 years (Glorennec *et al.*, 2017).

### Endocrine toxicity

Endocrine disrupting activity towards farm workers (Weng *et al.*, 2016). It inhibits androgen receptors and thus causes male reproductive dysfunction (Sheikh and Beg, 2021). It causes immaturity, degeneration and loss of spermatogonia in males rats and it is secreted in breast milk (Chrustek *et al.*, 2018). It also inhibits oestrogen sensitive cell proliferation (Sheikh and Beg, 2021).

## Food safety issues

Since permethrins are lipophilic compounds, with high values of octanol-water partition coefficient (log KOW), they tend to accumulate easily in fat tissues and accumulate in fish (Corcellas *et al.*, 2015b). Permethrin residues have been reported in tomatoes from Argentina (Mac *et al.*, 2018) and vegetables from markets in Accra, Ghana (Donkor *et al.*, 2016; Fosu *et al.*, 2017).

## Environmental toxicity and environmental behavior of concern

It is not highly soluble in water, has a low volatility and is not normally expected to leach to groundwater. It would also not be expected to persist in soil or water systems. It binds to the soil but can be broken by microorganisms and through photolysis (Branch, 2003; Lewis *et al.*, 2016). Permethrin is low in toxicity to birds, but highly toxic to aquatic life and honeybees.

**High bee toxicity:** Permethrin is highly toxic to bees (Maund *et al.*, 2012). There is evidence of impacts on a variety of bee species, but limited studies are available (Peterson *et al.*, 2021; Helson *et al.*, 1994). It is toxic to other beneficial insects such as predatory ground beetles and parasitoid wasps (Sánchez-Bayo, 2021).

**High aquatic toxicity:** Permethrin is extremely poisonous to fish and other aquatic creatures, whether they dwell in salt or fresh water (Tomlin, 2009; Lewis *et al.*, 2016). In fish, it can cause a delay in the synthesis of egg proteins (Brander, 2012). Permethrin causes developmental toxicities, aberrant vascular development, altered locomotor activities, and thyroid disturbance in fish, according to Xu *et al.* (2018) and Wu *et al.* (2020). Surface water pollution (Stehle and Schulz 2015; Werner and Young 2018) is proven in other countries.

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Carcinogenicity
- Neurotoxicity
- Reproductive toxicity
- High risk to children
- High bee toxicity
- High aquatic toxicity

## References

- Branch, E. M. (2003). Environmental Fate of Permethrin Heather Imgrund Environmental Monitoring Branch Department of Pesticide Regulation.
- Brander, S.M.; He, G.; Smalling, K.L.; Denison, M.S.; Cherr, G.N. (2012). *The in vivo estrogenic and in vitro anti-estrogenic activity of permethrin and bifenthrin*. 31, 2848–2855.
- Carlioni, M., Nasuti, C., Fedeli, D., Montani, M., Amici, A., Vadhana, M. D., & Gabbianelli, R. (2012). *Experimental gerontology. The impact of early life permethrin exposure on development of neurodegeneration in adulthood*. *Environ. Toxicol. Chem*, 47(1), 60-66.
- Carlioni, M., Nasuti, C., Fedeli, D., Montani, M., Vadhana, M. D., Amici, A., & Gabbianelli, R. (2013). *Early life permethrin exposure induces long-term brain changes in Nurr1, NF-kB and Nrf-2*. *Brain research*, 1515, 19-28.
- Chrutek, Agnieszka *et al.* (2018). “Current Research on the Safety of Pyrethroids Used as Insecticides.” *Medicina (Lithuania)* 54(4): 1–15.
- Corcellas C, Eljarrat E, Barcelo D. (2015b). *First report of pyrethroid bioaccumulation in wild river fish: A case study in Iberian river basins (Spain)*. *Environ Int*. 75:110-116.
- Corcellas C., Feo M.L., Torres J.P., Malm O., Ocampo-Duque W., Eljarrat E., Barceló D (2012). *Pyrethroids in human breast milk: Occurrence and nursing daily intake estimation*. *Environ. Int*. 2014; 47:17–22. doi: 10.1016/j.envint.2012.05.007.
- Donkor, A., Osei-Fosu, P., Dubey, B., Kingsford-Adaboh, R., Ziwu, C., Asante, I. (2016). *Pesticide residues in fruits and vegetables in Ghana: a review*. *Environmental Science and Pollution Research*, 23(19), 18966–18987. doi:10.1007/s11356-016-7317-6
- Drago, Bonny, Namrata S. Shah, and Samir H. Shah. (2014). *Acute Permethrin Neurotoxicity: Variable Presentations, High Index of Suspicion*. *Toxicology Reports* 1: 1026–28. <http://dx.doi.org/10.1016/j.toxrep.2014.09.007>.
- EPA. (2006). *Permethrin Facts (Reregistration Eligibility Decision (RED) Fact Sheet)* EPA 738-F-06-012 June 2006
- Falcioni, M. L., Nasuti, C., Bergamini, C., Fato, R., Lenaz, G., & Gabbianelli, R. (2010). *The primary role of glutathione against nuclear DNA damage of striatum induced by permethrin in rats*. *Neuroscience*, 168(1), 2-10.
- Fosu, P.O., Donkor, A., Ziwu, C. *et al.* (2017). *Surveillance of pesticide residues in fruits and vegetables from Accra Metropolis markets, Ghana, 2010–2012: a case study in Sub-Saharan Africa*. *Environ Sci Pollut Res* 24, 17187–17205. <https://doi.org/10.1007/s11356-017-9287-8>
- Gabbianelli, R., Falcioni, M. L., Cantalamessa, F., & Nasuti, C. (2009). *Permethrin induces lymphocyte DNA lesions at both Endo III and Fpg sites and changes in monocyte respiratory burst in rats*. *Journal of Applied Toxicology*, 29(4), 317-322.
- Gabbianelli, R., Palan, M., Flis, D. J., Fedeli, D., Nasuti, C., Skarydova, L., & Ziolkowski, W. (2013). *Imbalance in redox system of rat liver following permethrin treatment in adolescence and neonatal age*. *Xenobiotica*, 43(12), 1103-1110.
- Glorennec P., Serrano T., Fravallo M., Warembourg C., Monfort C., Cordier S., Viel J., Le Gléau F., Le Bot B., Chevrier C. (2017). *Determinants of children’s exposure to pyrethroid insecticides in western France*. *Environ. Int*. 2017; 104:76–82. doi: 10.1016/j.envint.2017.04.007.
- Helson, B.V., Barber, K.N. and Kingsbury, P.D. (1994). *Laboratory toxicology of six forestry insecticides to four species of bee (Hymenoptera: Apoidea)*. *Archives of environmental contamination and toxicology*, 27(1), pp.107-114.






























- Issam, C., Zohra, H., Monia, Z., & Hassen, B. C. (2011). *Effects of dermal sub-chronic exposure of pubescent male rats to permethrin (PRMT) on the histological structures of genital tract, testosterone and lipoperoxidation*. *Experimental and toxicologic pathology*, 63(4), 393-400.
- Jinghong, K & Jeffrey R.B. (2007). Neurotoxicity in murine striatal dopaminergic pathways following long-term application of low doses of permethrin and MPTP, Neurotoxicology Laboratory, Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA
- Joshi, Utsav *et al.* (2019). "A Permethrin Metabolite Is Associated with Adaptive Immune Responses in Gulf War Illness." *Brain, Behavior, and Immunity* 81: 545–59. <https://doi.org/10.1016/j.bbi.2019.07.015>
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016). *An international database for pesticide risk assessments and management*. *Human and Ecological Risk Assessment*. An International Journal, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- Mac Loughlin, Tomás M., Peluso, Ma.Leticia, Etchegoyen, Ma.Agustina, Alonso, Lucas L., Cecilia de Castro, Ma., Percudani, Ma.Cecilia, Marino, Damián J.G. (2018). *Pesticide residues in fruits and vegetables of the Argentine domestic market: occurrence and quality*. *Food Control*, doi: 10.1016/j.foodcont.2018.05.041
- Maund SJ, Campbell PJ, Giddings JM, Hamer MJ, Henry K, Pilling ED, Warinton JS, Wheeler JR. (2012). *Ecotoxicology of synthetic pyrethroids*. *Top Curr Chem*. 314:137-65. doi: 10.1007/128\_2011\_260. PMID: 22025065.
- Nasuti, C., Carloni, M., Fedeli, D., Di Stefano, A., Marinelli, L., Cerasa, L. S & Gabbianelli, R. (2014). *Effect of 17 $\beta$ -estradiol on striatal dopaminergic transmission induced by permethrin in early childhood rats*. *Chemosphere*, 112, 496-502.
- Nichelle Harriott. (2016). *Protecting pollinators in the age of Zika and other emerging mosquito diseases*. <https://www.beyondpesticides.org/assets/media/documents/Summer2016MosquitosAndPollinators.pdf>
- Oulhote, Y., & Bouchard, M. F. (2013). *Urinary metabolites of organophosphate and pyrethroid pesticides and behavioral problems in Canadian children*. *Environmental health perspectives*, 121(11-12), 1378-1384.
- Outhlote Y., Bouchard M. (2013). *Urinary metabolites of organophosphate and pyrethroid pesticides and behavioral problems in Canadian children*. *Environ. Health Perspect.* 121:1378–1384.
- Peterson, E.M., Green, F.B. and Smith, P.N. (2021). *Toxic responses of blue orchard mason bees (Osmia lignaria) following contact exposure to neonicotinoids, macrocyclic lactones, and pyrethroids*. *Ecotoxicology and Environmental Safety*, 208, p.111681.
- PPDB (2021): *Pesticide Properties DataBase, University of Hertfordshire* <http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/369.htm>
- Ramos-Chavez, Lucio A. *et al.* (2015). "A Permethrin/Allethrin Mixture Induces Genotoxicity and Cytotoxicity in Human Peripheral Blood Lymphocytes." *Journal of Toxicology and Environmental Health - Part A: Current Issues* 78(1): 7–14.
- Sánchez-Bayo, F. (2021). *Indirect Effect of Pesticides on Insects and Other Arthropods*. *Toxics* 9, 177. <https://doi.org/10.3390/toxics9080177>
- Sheikh IA. (2021). Beg MA. *Structural Aspects of Potential Endocrine-Disrupting Activity of Stereoisomers for a Common Pesticide Permethrin against Androgen Receptor*. *Biology (Basel)*. 11;10(2):143. doi: 10.3390/biology10020143. PMID: 33670303; PMCID: PMC7918290.
- Skolarczyk J, Pekar J, Nieradko-Iwanicka B. (2017). *Immune disorders induced by exposure to pyrethroid insecticides*. *Postepy Hig Med Dosw (Online)*. 8;71(0):446-453. doi: 10.5604/01.3001.0010.3827. PMID: 28665275.
- Stehle, Sebastian & Schulz, Ralf. (2015). *Agricultural insecticides threaten surface waters at the global scale*. *Proceedings of the National Academy of Sciences of the United States of America*. 112. 10.1073/pnas.1500232112.

- Tomlin, C. D. (2009). *The pesticide manual: a world compendium* (No. Ed. 15). British Crop Production Council.
- Toynton, K.; Luukinen, B.; Buhl, K.; Stone, D. (2009). *Permethrin Technical Fact Sheet; National Pesticide Information Center, Oregon State University Extension Services*. <http://npic.orst.edu/factsheets/Permtech.html>.
- Turkez, H., & Aydin, E. (2012). *The effects of taurine on permethrin-induced cytogenetic and oxidative damage in cultured human lymphocytes*. Arhiv za higijenu rada i toksikologiju, 63(1), 27.
- Turkez, H., & Aydin, E. (2013). *The genoprotective activity of resveratrol on permethrin-induced genotoxic damage in cultured human lymphocytes*. Brazilian Archives of Biology and Technology, 56, 405-411.
- Turkez, H., & Toğar, B. (2011). *Olive (Olea europaea L.) leaf extract counteracts genotoxicity and oxidative stress of permethrin in human lymphocytes*. The Journal of Toxicological Sciences, 36(5), 531-537.
- United States Environmental Protection Agency. (2015). Center for Integrative Research on Childhood Leukemia and the Environment. [https://cfpub.epa.gov/ncer/abstracts/index.cfm/fuseaction/display.abstractDetail/abstract\\_id/10648/report/F](https://cfpub.epa.gov/ncer/abstracts/index.cfm/fuseaction/display.abstractDetail/abstract_id/10648/report/F)
- Vadhana, M. D., Arumugam, S. S., Carloni, M., Nasuti, C., & Gabbianelli, R. (2013). *Early life permethrin treatment leads to long-term cardiotoxicity*. Chemosphere, 93(6), 1029-1034.
- Vadhana, M. D., Carloni, M., Nasuti, C., Fedeli, D., & Gabbianelli, R. (2011). *Early life permethrin insecticide treatment leads to heart damage in adult rats*. Experimental Gerontology, 46(9), 731-738.
- Weng et al., (2016). *Permethrin is Potential Thyroid – disrupting chemical: In vivo and in silico evidence*. Aquat Toxicol.
- Werner, I., & Young, T. M. (2018). *Pyrethroid insecticides - exposure and impacts in the aquatic environment*. In D. DellaSala & M. I. Goldstein (Eds.), Vol. 5. Encyclopedia of the Anthropocene (pp. 119-126). <https://doi.org/10.1016/B978-0-12-809665-9.09992-4>
- Wu, Y.; Li, W.; Yuan, M.; Liu, X. (2020). *The synthetic pyrethroid deltamethrin impairs zebrafish (Danio rerio) swim bladder development*. Sci. Total Environ. 701, 134870.
- Xu, C.; Li, X.; Jin, M.; Sun, X.; Niu, L.; Lin, C.; Liu, W. (2018). *Early life exposure of zebrafish (Danio rerio) to synthetic pyrethroids and their metabolites. A comparison of phenotypic and behavioral indicators and gene expression involved in the HPT axis and innate immune system*. Environ. Sci. Pollut. Res, 25, 12992–13003.

## Fenitrothion

Fenitrothion is an insecticide that is registered in **4 products** to control sucking and chewing pests on maize and wheat, mainly on stored grains. However, farmers in Kirinyaga und Murang'a also apply it to control pests on tomatoes, mangoes, sweet potatoes, rice, coffee, kale and maize (KOAN, 2020).

General aspects	
Registered products containing Fenitrothion	Delfa 1.01 % Dust Sumicombi 1.8% Dust Sumithion Super Wivokill
Manufacturing companies	Sichuan Saiwei Biological Engineering Co., Ltd., China Sumitomo Chemical Co., Japan.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Maize, Wheat
Pest	Larger grain borer, Maize weevils, Red flour beetles,
Alternatives*	Metarhizium acridum, Nimbecidine, Magneto
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021  
 \*\* Pesticide Properties Database: University of Hertfordshire, 2021  
 Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Fenitrothion causes high human toxicity and can induce significant damage of the brain, lung, liver, and kidney leading to imbalance in their functionality (Abdel-Ghany *et al.* 2016; Matsuda *et al.*, 2011). It is considered to be an endocrine disrupter and cholinesterase inhibitor (Lewis *et al.*, 2016) but does not have carcinogenic or genotoxic potential (EFSA, 2006).

### Neurotoxicity disrupting activity

As an organophosphate it disrupts neurotransmitters in the brain (Abdel-Ghany *et al.*, 2016).

### Hepatotoxicity

It disrupts the hepatobiliary system (Taib *et al.*, 2013)

### Reproductive toxicity

Morphological changes of sperms and testes in rats (Abdel-Ghany *et al.*, 2016) and it is fetotoxic (Turner, 2002).

## Food safety issues

Fenitrothion levels above MRLs were reported in spinach, lettuce, cabbage, tomato and onion from Nigeria (Akan *et al.*, 2013). A similar trend has been reported for green beans, lettuce, watermelon and green pepper from Ghana (Fosu *et al.*, 2017). Fenitrothion has also been reported in honey from different locations in Colombia at varied concentrations within and exceeding the stipulated MRL (Lopez *et al.*, 2014).

## Environmental toxicity and environmental behavior of concern

It has a low aqueous solubility and a low potential for leaching to groundwater. It is not expected to be persistent in soil or water systems. Fenitrothion has the potential for volatilization. However, the use as microencapsulated formulation will reduce this potential (EFSA, 2006). It is moderately toxic to mammals, considered to be an endocrine disrupter and a cholinesterase inhibitor.

**High bee toxicity:** There is evidence of the toxicity to bees and other pollinators. These impacts are considered moderate, but scale up when used with other pesticides (Brittain *et al.*, 2010; Vighi *et al.*, 2010).

**High aquatic toxicity:** Fenitrothion changed blood parameters and the histopathology of many organs in fish (Salam *et al.*, 2015; Ahmed *et al.*, 2015; Ahmed *et al.*, 2016; Hossain *et al.*, 2015).

**Medium to high bird toxicity:** Fenitrothion is highly toxic to birds by acute oral and dietary routes (National Registration Authority for Agricultural and Veterinary Chemicals, 1999). Toxicity effects have been found in birds on savannas in northern Senegal (Mullie 2021; Mullie & Keith 1993). Both compounds (fenitrothion & chlorpyrifos) were shown to have several adverse direct and indirect impacts on the avian community, with fenitrothion showing a stronger and longer lasting, dose dependent impact than chlorpyrifos.

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced. Proposed withdrawal in Kenya should be based on:

- Neurotoxicity
- Misuse by farmers
- High aquatic toxicity
- High bird toxicity
















## References

- Abdel-Ghany, R., Mohammed, E., Anis, S., & Barakat, W. (2016). *Impact of Exposure to Fenitrothion on Vital Organs in Rats*. Journal of Toxicology, 2016, 1–18. <https://doi.org/10.1155/2016/5609734>
- Ahmed S.I., Ahmmed M.K., Ghosh S.K., Islam M.M., Shahjahan M. (2015). *Histo-architectural changes of intestinal morphology in Zebra fish (Danio rerio) exposed to Sumithion*. Res. Agric., Livest. Fish 2:499–506.
- Ahmed S.I., Zahangir M.M., Haque F., Ahmmed M.K., Shahjahan M. (2016). *Alteration of blood glucose and hemoglobin levels in zebrafish exposed to sumithion*. Progress. 27:216–221.
- Akan J. C., Jafiya L., Mohammed Z., Abdulrahman F. I. (2013). *Organophosphorus pesticide residues in vegetables and soil samples from alau dam and gongulong agricultural areas, Borno State, Nigeria*. International Journal of Environmental Monitoring and Analysis, 1(2) : 58-64
- Brittain, C.A., Vighi, M., Bommarco, R., Settele, J. and Potts, S.G. (2010). *Basic and Applied Ecolog. Impacts of a pesticide on pollinator species richness at different spatial scales*. 11 (2), pp.106-115.
- European Food Safety Authority (EFSA). (2006). *Conclusion regarding the peer review of the pesticide risk assessment of the active substance fenitrothion*. EFSA Journal, 4(2), 59r.
- Fosu, P.O., Donkor, A., Ziwu, C. et al. (2017). *Surveillance of pesticide residues in fruits and vegetables from Accra Metropolis markets, Ghana, 2010–2012: a case study in Sub-Saharan Africa*. Environ Sci Pollut Res 24, 17187–17205. <https://doi.org/10.1007/s11356-017-9287-8>
- Hossain S., Khatun M.H., Rahman M.K., Shahjahan M. (2015). *Impacts of sumithion on blood glucose and some hematological parameters in common carp*. Int. J. Environ 5:8–13.
- KOAN-Kenyan Organic Agricultural Network. (2020). *Pesticide use in Kirinyaga and Murang'a county*. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf)
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016). *An international database for pesticide risk assessments and management. Human and Ecological Risk Assessment*. An International Journal, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- López R., Ahumada, D., Díaz, A., Guerrero, J. (2014). *Evaluation of pesticide residues in honey from different geographic regions of Colombia*. Food Control; 37, 33–40. <https://doi.org/10.1016/j.foodcont.2013.09.011>
- Matsuda, K. et al. (2011). *Assessment of the severity of organophosphate (fenitrothion) poisoning based on its serum concentration and clinical parameters*. Clin. Toxicol. (Phila.) 49, 820–827. <https://doi.org/10.3109/15563650.2011.617306>.
- Mullié W.C., Keith J.O. (1993). *The effects of aerially applied fenitrothion and chlorpyrifos on birds in the savannah of northern Senegal*. J Appl Ecol 30: 536–550.
- Mullie, W.C., (2021). *Don't kill your allies. The impact of chemical and biological locust and grasshopper control on birds, 170 Pages*. PhD thesis, Wageningen University, Wageningen, The Netherlands.
- National Registration Authority for Agricultural and Veterinary Chemicals. (1999). *The NRA review of fenitrothion interim report*. <https://apvma.gov.au/sites/default/files/publication/15281-fenitrothion-interim-report-summary.pdf>
- PPDB. (2021). *Pesticide Properties DataBase, University of Hertfordshire*. <http://sitem.herts.ac.uk/aeru/ppdb/en/Reports/369.htm>
- Salam M.A., Shahjahan M., Sharmin S., Haque F., Rahman M.K. (2015). *Effects of sub-lethal doses of an organophosphorus insecticide sumithion on some hematological parameters in common carp, Cyprinus carpio*. Pakistan J. Zool; 47:1487–1491
- Taib, I., Budin, S., Ghazali, A., Jayusman, P., Louis, S., & Mohamed, J. (2013). *Fenitrothion induced oxidative stress and morphological alterations of sperm and testes in male sprague-dawley rats*. Clinics, 68(1), 93–100. [https://doi.org/10.6061/clinics/2013\(01\)oa15](https://doi.org/10.6061/clinics/2013(01)oa15)
- Turner, K. J. (2002). *Effects of in Utero Exposure to the Organophosphate Insecticide Fenitrothion on Androgen-Dependent Reproductive Development in the Crl:CD(SD)BR Rat*. Toxicological Sciences, 68(1), 174–183. <https://doi.org/10.1093/toxsci/68.1.174>
- Vighi, M., Settele, J. and Potts, S.G. (2010). *The impact of an insecticide on insect flower visitation and pollination in agricultural landscape*. Agricultural and Forest Entomology, 12, pp.259-266.



## Dimethoate

Dimethoate is an organophosphate insecticide. It is registered in **13 products** to control various insect pests on coffee, potatoes, tobacco and cotton. Although it is not registered for foliar spray in vegetables and fruits, farmers in Kirinyaga and Murang'a counties are using it on cabbage, maize and tomatoes (KOAN, 2020).

General aspects	
Registered products containing Dimethoate	Agrothoate 40 EC Alphasime 85 ULV Danadim Blue 40 EC Dimekil 40 EC Dimeton 40 EC Domino 40 EC Ethoate Hangthoate 400 EC Hygro 40% EC Ogor 40 EC Rogor L 40 EC Taigor 40 EC Twigathoate 40% EC
Manufacturing companies	Asiatic Agricultural Industries, Singapore. Cheminova A/S, Denmark Hyderabad Chemical Products Ltd. India. Isagro SPA, Italy Jiangsu Tenglong Biological & Medical Co. Ltd., China/Hangzhou Jike Company Ltd., China National Company for Agrochemicals Agrochem, Egypt Novus-Bridge Consultants Rallis Ltd., India.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Potatoes, Coffee, Cotton, Tobacco
Pest	Aphids, Potato tuber moth, Thrips, Bollworms, Whiteflies, Caterpillars
Alternatives*	Ozoneem, Achook, Nemroc (Azadirachtin), AMINEM XY16 Liquid Emulsion (Carvacrol 2% w/v), NEMguard® (Polysulphide Formulation) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur Oxymatrine, pyrethroids
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  

**Environmental Health\*\*****Bee Toxicity****Fish Toxicity****Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern**

Dimethoate is an organophosphate that inhibits the acetylcholinesterase (AChE). When AChE inhibition exceeds 70-75%, acute poisoning results in increased sweating and salivation, broncho constriction, miosis, increased gastrointestinal mobility and tremors, dizziness, mental confusion and convulsions (Krieger, 2001). Exposure results in cytogenetic damage, as well as genotoxic and immunotoxin effects (Nazam *et al.*, 2020). It produces irreversible acute hypotension and shock, as well as toxic cardiomyopathy with a reduced ejection fraction (Mohanapriya, 2017).

The toxicity of dimethoate results in deleterious effects on many organs and systems in human and other mammals such as the liver, kidney, pancreas, brain, nervous system, immune system, and reproductive system (Bakir, 2020).

**Neurotoxic**

Dimethoate is a strong inhibitor of acetylcholinesterase and is neurotoxic when consumed, inhaled, or absorbed via the skin (Nazam *et al.*, 2015). Dimethoate is reported to induce a variety of symptoms leading to cholinergic morbidity among farm workers and pesticide handlers. It is also reported to affect neurological and cognitive function among other health effects in humans and nontarget mammalian species (Sinha and Shukla, 2003; Young *et al.*, 2006).

**Genotoxic**

It is a confirmed genotoxicant, inducing cytogenetic changes including sister chromatid exchanges in human lymphocytes, and micronucleus formation and chromosomal aberration under sub-chronic conditions in mice (Ayed-Bousema, 2012).

**Mutagenic**

This pesticide can be mutagenic and alter cell division and alter reproductive and central nervous systems. Omethoate, the main metabolite of dimethoate, was concluded to be an *in vivo* mutagen (EFSA, 2018). Positive gene mutation effects were observed in bacterial and mammalian cells *in vitro* with dimethoate without appropriate *in vivo* follow-up (Reuber, 1984; Duan *et al.*, 2017). Since a mutagenic potential could not be excluded for dimethoate, no threshold for this effect is assumed and therefore toxicological reference values could not be established.

**Carcinogenicity**

It increases the risk of prostatic cancer among male applicators (Pardo *et al.* 2020).

**Endocrine disruption**

From a scientific perspective, the endocrine disrupting potential of dimethoate could not be excluded. Interac-



tion of dimethoate with the thyroid pathway in mammals and wildlife cannot be excluded.

### Reproductive and development toxicity

Negative impact on reproductive performance of male mice (Faraq *et al.*, 2007)

## Food safety issues

Dimethoate poses a high food safety concern. Its persistence in crops and soils may further enhance its propensity of adverse health consequences in humans and other non-target species. The residue of dimethoate and its analog (omethoate) have been found in many food items, including cow milk (Ramon-Yusuf *et al.*, 2017). In peri-urban Nairobi, Mutai *et al.* (2015) observed that kale and French beans had up to 700 g/kg of dimethoate residues. Dimethoate and omethoate were found in tomatoes from Machakos (unpublished data Route to Food Initiative, 2020). Dimethoate has been reported in tomato and peas from Cameroon and Nigeria, respectively (Luc *et al.*, 2019) and in fruits and vegetables from the Mediterranean region (Verger *et al.*, 2020).

## Environmental toxicity and environmental behavior of concern

Dimethoate is highly soluble in water, has low groundwater leaching potential and is volatile. It is non-persistent in soil, mobile but does not normally persist in aerobic aquatic systems.

**Soil effects:** Although adsorption to soils is weak, studies have found that organic matter content influences soil retention (Vagi *et al.*, 2010).

**Water effects:** Due to its strong hydrophilic nature, surface and groundwater contamination must be considered. This insecticide is present in high concentrations in many waterways. It has been detected in surface waters in the US and groundwaters in Saudi Arabia and China (Ensminger *et al.*, 2009; El-Saeid *et al.* 2011; Gao *et al.* 2009).

**Bee toxicity:** Highly toxic to honeybees (Vrushali and Chidanand, 2018; Aupinel *et al.*, 2007). It has been demonstrated that toxicity is linked with the size of the bee, and smaller bee species are more affected (Uhl *et al.*, 2016; Biddinger *et al.*, 2013). There is evidence that usage can be linked with lower pollination and yields in sunflower cultivation (Orornje *et al.*, 2007).

**Aquatic toxicity:** Dimethoate has high toxicity to fish and invertebrates (Ashwini *et al.*, 2020; Imtiyaz *et al.*, 2016; Dogan *et al.*, 2011; Ratageri *et al.*, 2006, Andersen *et al.*, 2009).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Genotoxicity and mutagenic potential, which might induce cancer
- Effect on reproduction (insufficient data)
- Food safety
- Farmers misuse
- Neurotoxicity
- High bee toxicity
- High aquatic toxicity




























## References

- Andersen, T.H., Tiørnhoj, R., Wollenberger, L., Slothuus, T., Baun, A., 2009. Acute and chronic effects of pulse exposure of *Daphnia magna* to dimethoate and pirimicarb. *Environmental Toxicology and Chemistry* 25(5): 1187-1195. <https://doi.org/10.1897/05-465R1.1>
- Ashwini Pandurang Pawar *et al.*, (2020). Effects of salinity and temperature on the acute toxicity of the pesticides, dimethoate and chlorpyrifos in post-larvae and juveniles of the whiteleg shrimp. *Aquaculture Reports*, Volume 16, 2020. <https://doi.org/10.1016/j.aqrep.2019.100240>.
- Bakır E, Sarıözkan S, Endirlik BÜ, Kılıç AB, Yay AH, Tan FC, Eken A, Türk G. Cherry laurel fruit extract counters dimethoate-induced reproductive impairment and testicular apoptosis. *Arh Hig Rada Toksikol.* 2020 Dec 31;71(4):329-338. doi: 10.2478/aiht-2020-71-3412.
- Aupinel, P., Fortini, D., Michaud, B., Marolleau, F., Tasei, J.-N., Odoux, J.-F., 2007. Toxicity of dimethoate and fenoxycarb to honey bee brood (*Apis mellifera*), using a new in vitro standardized feeding method. *Pest Management Science* 63 (11): 1090-1094. <https://doi.org/10.1002/ps.1446>
- Ayed-Boussema, I.; Rjiba, K.; Mnasri, N.; Moussa, A.; Bacha, H (2012). Genotoxicity evaluation of dimethoate to experimental mice by micronucleus, chromosome aberration tests, and comet assay. *Int. J. Toxicol.* 231, 78–85.
- Biddinger, D.J., Robertson, J.L., Mullin, C., Frazier, J., Ashcraft, S.A., Rajotte, E.G., Joshi, N.K. and Vaughn, M., 2013. Comparative toxicities and synergism of apple orchard pesticides to *Apis mellifera* (L.) and *Osmia cornifrons* (Radoszkowski). *PloS one*, 8(9), p.e72587.
- Duan, X., Yang, Y., Wang, S., Feng, X., Wang, T., Wang, P., Liu, S., Li, L., Yao, W., Cui, L., Wang, W., 2017. Changes in the expression of genes involved in cell cycle regulation and the relative telomere length in the process of canceration induced by omethoate. *Tumor Biology*, 39 (7) <https://doi.org/10.1177/1010428317719782>
- El-Saeid MH, Al-Turki AM, Al-Wable MI, Abdel-Nasser G (2011) Evaluation of pesticide residues in Saudi Arabia ground water. *Res J Environ Sci* 5(2):171–178
- Ensminger M, Bergin R, Spurlock F, Goh KS. (2011). Pesticide concentrations in water and sediment and associated invertebrate toxicity in Del Puerto and Orestimba Creeks, California, 2007-2008. *Environ Monit Assess.*, 175(1-4):573-87. doi: 10.1007/s10661-010-1552-y.
- Farag, A.T., El-Aswad, A.F., Shaaban, N.A., 2007. Assessment of reproductive toxicity of orally administered technical dimethoate in male mice. *Reproductive Toxicology*, 23 (2): 232-238. <https://doi.org/10.1016/j.reprotox.2006.12.003>.
- Gao J, Liu L, Liu X, Zhou H, Lu J, Juang S, Wang Z (2009) The occurrence and spatial distribution of organophosphorus pesticides in Chinese surface water. *Bull Environ Contam Toxicol* 82:223–229.
- KOAN-Kenyan Organic Agricultural Network, 2020. Pesticide use in Kirinyaga and Murang'a county. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf)
- Krieger R. (2001). *Handbook of pesticide toxicology: Principles and agents*. Academic Press
- Luc I., Renwei H., Lionel L., Anaïs P. (2019). Sub-Saharan Africa total diet study in Benin, Cameroon, Mali and Nigeria: Pesticides occurrence in foods. *Food Chemistry: X*, 2, <https://doi.org/10.1016/j.fochx.2019.100034>
- Mutai C, Inonda R, Njage E, Ngeranwa J. 2015. Determination of pesticide residues in locally consumed vegetables in Kenya. *Afr J Pharmacol Ther.* 4:1–6.
- Nazam N, Lone MI, Hamid A, Qadah T, Banjar A, Alam Q, Saeed M, Ahmad W. (2020). Dimethoate Induces DNA Damage and Mitochondrial Dysfunction Triggering Apoptosis in Rat Bone-Marrow and Peripheral Blood Cells. *Toxics.*, 8(4):80. doi: 10.3390/toxics8040080.

- Nazam, N.; Shaikh, S.; Lone, M.I.; Sharma, M.; Ahmad, W. (2015). Combined in silico and in vivo studies shed insights into the acute acetylcholinesterase response in rat and human brain. *Biotech. Appl. Biochem.*, 62, 407–415.
- Orornje, M.L., Nyamasyo, G. and Nderitu, J., (2007). Effects of Insecticide Applications on Sunflower (*Helianthus annuus* L.) Pollination in Eastern Kenya.
- Pardo L., Freeman L., Lerro C., Andreotti G., Hofmann J., Parks C., Sandler D., Lubin J., Blair A., Koutros S. (2020). Pesticide exposure and risk of aggressive prostate cancer among private pesticide applicators. *Environmental Health*. 19. 10.1186/s12940-020-00583-0.
- Mohanapriya P., Sudharsan S., Sathishkumar J.T., Muthukrishnan, K. (2017). Dimethoate Poisoning Induced Toxic Cardiomyopathy – Case Report. *JMSCR*, (5)11. DOI: <https://dx.doi.org/10.18535/jmscr/v5i11.21>.
- Ramon-Yusuf S.B, Aliu Y.O , Salawu O.A , Chahoud I and Ambali S.F (2017). Maternal and foetal toxicity induced by exposure to mixture of dimethoate and cypermethrin in albino rats. Vol. 9(6), pp. 59-65, June 2017 DOI: 10.5897/JTEHS2017.0381
- Ratageri, R., Taranath, T. and Lakshman, H., 2006. Toxicity of Dimethoate on Primary Productivity of a Lentic Aquatic Ecosystem: A Microcosm Approach. *Bulletin of Environmental Contamination and Toxicology*, 76: 373. <https://doi.org/10.1007/s00128-006-0931-0>
- Reuber, M.D., 1984. Carcinogenicity of dimethoate. *Environmental Research*, 34(2):193-211, [https://doi.org/10.1016/0013-9351\(84\)90089-6](https://doi.org/10.1016/0013-9351(84)90089-6).
- Sinha C, Shukla, GS (2003). Species variation in pesticide induced blood-brain barrier dysfunction. *Hum. Exp. Toxicol*. 22:647-652
- Uhl, P., Franke, L.A., Rehberg, C., Wollmann, C., Stahlschmidt, P., Jeker, L. and Brühl, C.A., 2016. Interspecific sensitivity of bees towards dimethoate and implications for environmental risk assessment. *Scientific reports*, 6(1), pp.1-7.
- Vagi MC, Petsas AS, Kostopoulou MN, Lekkas TD (2010) Adsorption and desorption processes of the organophosphorus pesticides, dimethoate and fenthion, onto three Greek agricultural soils. *Int J Environ Anal Chem* 90:369–389.
- Verger P., Neveen, A., Marwa, A., Ahmad B., Al-Yousfi (2020). Occurrence of pesticide residues in fruits and vegetables for the Eastern Mediterranean Region and potential impact on public health. *Food Control*, 119, 107457. <https://doi.org/10.1016/j.foodcont.2020.107457>
- Vrushali V. P & Chidanand S. P. (2018). Toxicity and Poisoning Symptoms of selected Insecticides to Honey Bees (*Apis mellifera mellifera* L.). *Arch Biol Sci.*; 70(1): 5-12 <https://doi.org/10.2298/ABS170131020P>.
- Young JG, Eskenazi B, Gladstone EA, Bradham A, Pedersen L, Johnson C (2006). Association between in-utero organophosphate pesticide exposure and abnormal reflexes in neonates. *Neurotoxicology* 26:199-209.

## Flubendiamide

Flubendiamide which is the first representative of a new chemical insecticide class - the diamides. In contrast to other insecticide classes targeting the insect nervous system, flubendiamide acts at receptors in insect muscles causing an immediate cessation of feeding and thus avoids crop damage. It is registered in **2 products** to control various insect pests on various vegetables and maize. Farmers are using it to control insect pests on rice, kale, maize, tomatoes and cabbage (KOAN, 2020).

General aspects	
Registered products containing Flubendiamide	Belt 480 SC Tihan OD 175
Manufacturing companies	Bayer AG Germany. Nihon N.C Ltd, Germany; Bayer AG, Germany
HHP	Yes
Withdrawn in Europe	No
Crops treated	Cabbages, Tomatoes, Maize, Chillies, Potatoes, Broccoli
Pest	Diamond back moth, Caterpillars, Maize stalk borers, Armyworm, Aphids, Mealybugs, Thrips, Whiteflies
Alternatives*	-
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021  
 \*\* Pesticide Properties Database: University of Hertfordshire, 2021  
 Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Flubendiamide is not acutely toxic through dermal, oral and inhalation routes.

It is also not a skin and eye irritant nor a skin sensitizer (European Commission, 2004; European Commission, 2012).

In long term exposure, the primary target organs that are affected include liver, kidney, eyes and thyroid (US EPA, 2008). It enhances adipogenesis (Sun *et al.*, 2018). It has documented immunological effects (cytotoxic in nature) (Mandil *et al.*, 2020).

## Reproduction and development toxicity

The effects observed in the reproductive studies suggest that it has a risk of causing harm to the unborn child and breast-fed babies (European Food Safety Authority, 2013).

## Food safety issues

It takes a long time to degrade from capsicum (Buddidathi *et al.*, 2015). Flubendiamide residues were reported in cucumbers (Sharma *et al.*, 2017), in okra fruits (Das *et al.*, 2012) and on brinjal fruits grown in India (Chawla *et al.*, 2011).

## Environmental toxicity and environmental behavior of concern

Flubendiamide is highly persistent in soil and has a low potential for groundwater exposure. It has a low risk to honeybees, soil microorganisms, birds and mammals (European Commission (2002a, 2002b) and SETAC (2001).

**Low bee toxicity:** Appears to have limited or moderate impacts on bees. It is mainly meant for use against lepidopteran (caterpillar) pests (Sarkar *et al.*, 2014; Gradisch *et al.*, 2012). It interferes with calcium uptake in bee neurons (Kadala *et al.*, 2020). Data and studies available are limited.

**Medium to high aquatic risk:** (Pesticide Properties Database, 2019)

## Pesticide's alternatives

No alternatives

## Proposed action in Kenya

A withdrawal is not necessarily proposed as flubendiamide poses less risk compared to other insecticides.

Active ingredient may be **retained**, provided that risk mitigation measures, extensive training programs and Integrated Pest Management strategies are in place.




























## References

- Buddidathi, R., Mohapatra, S., Siddamallaiiah, L., Manikrao, G., & Hebbar, S. S. (2015). Dissipation pattern of flubendiamide residues on capsicum fruit (*Capsicum annum* L.) under field and controlled environmental conditions. *Journal of Environmental Science and Health, Part B*, 51(1), 44–51. <https://doi.org/10.1080/03601234.2015.1080496>
- Chawla S, Patel AR, Patel HK, Shah PG. (2011). Dissipation of flubendiamide in/on Brinjal (*Solanum melongena*) fruits. *Environ Monit Assess*. 183:1–4.
- Das SK, Mukherjee I, Das SK. (2012). Dissipation of flubendiamide in/on okra (*Abelmoschus esculenta* L. Moench) fruits. *Bull Environ Contam Toxicol*. 88:381–384.
- EFSA (European Food Safety Authority), 2013. Peer Review Report to the conclusion regarding the peer review of the pesticide risk assessment of the active substance flubendiamide.
- European Commission, 2002a. Guidance Document on Terrestrial Ecotoxicology Under Council Directive 91/414/EEC. SANCO/10329/2002 rev.2 final, 17 October 2002.
- European Commission, 2002b. Guidance Document on Aquatic Ecotoxicology Under Council Directive 91/414/EEC. SANCO/3268/2001 rev 4 (final), 17 October 2002.
- European Commission, 2004. Guidance Document on Dermal Absorption. SANCO/222/2000 rev. 7, 19 March 2004.
- European Commission, 2012. Guidance Document on the Assessment of the Equivalence of Technical Materials of Substances Regulated under Council Directive 91/414/EEC. SANCO/10597/2003 – rev. 10.1, 13 July 2012.
- Gradish, A.E., Scott-Dupree, C.D., Frewin, A.J. and Cutler, G.C., 2012. Lethal and sublethal effects of some insecticides recommended for wild blueberry on the pollinator *Bombus impatiens*. *The Canadian Entomologist*, 144(3), pp.478-486.
- Kadala, A., Charreton, M., & Collet, C. (2020). Flubendiamide, the first phthalic acid diamide insecticide, impairs neuronal calcium signalling in the honey bee's antennae. *Journal of Insect Physiology*, 125, 104086. <https://doi.org/10.1016/j.jinsphys.2020.104086>
- KOAN-Kenyan Organic Agricultural Network, 2020. Pesticide use in Kirinyaga and Murang'a county. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Countries-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Countries-2020.pdf)
- Mandil, R., Prakash, A., Rahal, A., Singh, S. P., Sharma, D., Kumar, R., & Garg, S. K. (2020). In vitro and in vivo effects of flubendiamide and copper on cyto-genotoxicity, oxidative stress and spleen histology of rats and its modulation by resveratrol, catechin, curcumin and  $\alpha$ -tocopherol. *BMC Pharmacology and Toxicology*, 21(1). <https://doi.org/10.1186/s40360-020-00405-6>
- Pesticide Fact Sheet on Flubendiamide (2008) US Environmental Protection Agency. (<http://www.epa.gov/op-prd001/factsheet/flubendiamide.pdf>).
- Sarkar, S., Dutta, M. and Roy, S., 2014. Potential toxicity of flubendiamide in *Drosophila melanogaster* and associated structural alterations of its compound eye. *Toxicological & Environmental Chemistry*, 96(7), pp.1075-1087.
- SETAC (Society of Environmental Toxicology and Chemistry), 2001. Guidance Document on Regulatory Testing and Risk Assessment procedures for Plant Protection Products with Non-Target Arthropods. ESCOR 2.
- Sharma, K.K.; Bhushan, V. Shashi; Rao, Cherukuri S. *et al.* (2017). Persistence, dissipation and consumer risk assessment of a combination formulation of flubendiamide and deltamethrin on Cucumber. *Food Additives & Contaminants: Part A*, (35), <https://doi.org/10.1080/19440049.2017.1416678>
- Sun, Q., Lin, J., Peng, Y., Gao, R., & Peng, Y. (2018). Flubendiamide Enhances Adipogenesis and Inhibits AMPK $\alpha$  in 3T3-L1 Adipocytes. *Molecules*, 23(11), 2950. <https://doi.org/10.3390/molecules23112950>



## Flufenoxuron

Flufenoxuron is an insecticide to control mites. It is registered in **1 product** to control mites on cabbage.

General aspects	
Registered products containing Flufenoxuron	Cascade 10% DC
Manufacturing companies	BASF Agri, France / BASF SE, Nairobi.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Cabbages
Pest	Mites
Alternatives*	Neem: Magneto, Nimbecidine, Trilogy (Azadirachtin) Oxymatrine, pyrethroids Spirotetramat, Sulphur, Acrinathrin
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  
<p>* Safer inputs database: Kenya Organic Agriculture Network, 2021</p> <p>** Pesticide Properties Database: University of Hertfordshire, 2021</p> <p>Note: green circle = low; orange circle = medium; red circle = high</p>	

## Human health effects of concern

Flufenoxuron is of low acute oral toxicity. It is not acutely toxic by skin contact or after inhalation. It is not irritant to skin or eyes. It is not a skin sensitizer (European Commission, 2003) (European Commission, 2004b) (European Commission, 2009).



However, poisoning can result to a coma, circulatory shock with severe hypotension, metabolic acidosis, and eventually rhabdomyolysis (Jeong *et al.* 2014; Jeong *et al.* 2010). It causes decreased blood parameters like haematocrit and haemoglobin (Health and safety executive, 1997).

In conclusion, severe lactic acidosis, shock, elevation of cardiac enzyme levels, and global left ventricular hypokinesia can result from human poisoning with flufenoxuron-containing insecticide (Woo and Lim 2015).

### Reproductive toxicity

It has been shown to disrupt early pregnancy in pigs via cell death through endoplasmic reticulum and mitochondrial dysfunction (Bae *et al.*, 2021).

### Food safety issues

Flufenoxuron was reported in olive oil from Greece at levels exceeding MRLs (Likudis *et al.*, 2014) and in green tea leaves (Cho *et al.*, 2014).

### Environmental toxicity and environmental behavior of concern

Flufenoxuron has a low aqueous solubility, is non-volatile and is not expected to leach to groundwater. It is moderately persistent in soils but will degrade quickly in aquatic systems in the presence of sunlight. Whilst it has a low mammalian toxicity it does have a high potential to bioaccumulate.

**Medium bee toxicity:** Considered a moderately toxic pesticide to bees. Limited data and studies available (Costa *et al.*, 2014; Shaurub *et al.*, 2018). In Kenya has mainly been used to control lepidopteran (caterpillar) pests.

**High aquatic toxicity:** (Pesticide Properties Database, 2019)

### Pesticide's alternatives

No alternatives

### Proposed action in Kenya

A withdrawal is not proposed as flubendiamide is posing less risk than other insecticides.




























Active ingredient that may be **retained**, assuring that necessary mitigation measures, extensive training programs and Integrated Pest Management strategies are in place.

## References

- Bae, H., You, S., Lim, W., & Song, G. (2021). Flufenoxuron disturbs early pregnancy in pigs via induction of cell death with ER-mitochondrial dysfunction. *Journal of Hazardous Materials*, 401, 122996. <https://doi.org/10.1016/j.jhazmat.2020.122996>
- Cho, Soon-Kil; Abd El-Aty, A.M.; Rahman, Md. Musfiqu; Choi, Jeong-Heui; Shim, Jae-Han (2014). Simultaneous multi-determination and transfer of eight pesticide residues from green tea leaves to infusion using gas chromatography. *Food Chemistry*, 165, 532–539. doi: 10.1016/j.foodchem.2014.05.145
- Costa, E.M., Araujo, E.L., Maia, A.V., Silva, F.E., Bezerra, C.E. and Silva, J.G., (2014). Toxicity of insecticides used in the Brazilian melon crop to the honey bee *Apis mellifera* under laboratory conditions. *Apidologie*, 45(1), pp.34-44.
- EFSA (European Food Safety Authority), 2011. Peer Review Report to the conclusion regarding the peer review of the pesticide risk assessment of the active substance flufenoxuron.
- European Commission, 2002a. Guidance Document on Terrestrial Ecotoxicology Under Council Directive 91/414/EEC. SANCO/10329/2002 rev.2 final, 17 October 2002.
- European Commission, 2002b. Guidance Document on Aquatic Ecotoxicology Under Council Directive 91/414/EEC. SANCO/3268/2001 rev 4 (final), 17 October 2002.
- European Commission, 2002c. Guidance Document on Risk Assessment for Birds and Mammals Under Council Directive 91/414/EEC. SANCO/4145/2000.
- European Commission, 2003. Guidance document on assessment of the relevance of metabolites in groundwater of substances regulated under council directive 91/414/EEC. SANCO/221/2000-rev 10-final, 25 February 2003.
- European Commission, 2004b. Guidance document on Dermal Absorption. SANCO/22/200 rev. 7, 19 March 2004.
- European Commission, 2009. Guidance document on the assessment of the equivalence of technical materials of substances regulated under Council Directive 91/414/EEC. Sanco/10597/2003 –rev. 8.1, May 2009.
- Jeong, Ho Hyung, Seok Ran Yeom, Sang Kyoong Han, and Sung Wook Park. (2014). Rapidly Progressive Lactic Acidosis in Patients with Flufenoxuron Poisoning. *Hong Kong Journal of Emergency Medicine* 21(3): 181–84.
- Jeong, Jinwoo *et al.* (2010). A Case of Human Poisoning with a Flufenoxuron-Containing Insecticide.” *Clinical Toxicology* 48(1): 87–89.
- Likudis Z., Vassiliki C., Andreas V., Apostolopoulos C. (2014). Determination of pesticide residues in olive oils with protected geographical indication or designation of origin. *International Journal of Food Science and Technology*, 49, 484–492
- Shaurub, E.S.H., Zohdy, N.Z., Abdel-Aal, A.E. and Emara, S.A., (2018). Effect of chlorfluazuron and flufenoxuron on development and reproductive performance of the black cutworm, *Agrotis ipsilon* (Hufnagel)(Lepidoptera: Noctuidae). *Invertebrate reproduction & development*, 62(1), pp.27-34.
- Woo JH, Lim YS. Severe human poisoning with a flufenoxuron-containing insecticide: Report of a case with transient myocardial dysfunction and review of the literature. *Clin Toxicol (Phila)*. 2015 Jul; 53(6):569-72. doi: 10.3109/15563650.2015.1040158

## Omethoate

Omethoate is a systemic organophosphorus insecticide and acaricide, available as a soluble concentrate. It is the breakdown product of dimethoate but also sold in **1 product** in Kenya.

General aspects	
Registered products containing Omethoate	Folimat 500 SL
Manufacturing companies	Arysta LifeScience Corporation, Japan.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Coffee
Pest	-
Alternatives*	-
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Omethoate can accumulate for a long period of time after entering the body, which becomes harmful to human health (Rong *et al.*, 2015; Sieke *et al.*, 2018).

Accumulating studies have concluded that long-term, low-dose exposure to omethoate as an organophosphate, is linked to human tumorigenesis, adverse reproductive outcomes, and neurological and neurobehavioral func-

tion abnormalities (Duan *et al.*, 2017a; Weichenthal *et al.*, 2010). Omethoate exposure affects different organs including the lung, gastrointestinal tract, liver, brain and cardiomyocytes (Wang *et al.*, 2016), and contributes to a variety of health effects, such as depressive-like symptoms, prevalence of diabetes, and even chromosomal DNA damage (Qiao *et al.*, 2017; Wang *et al.*, 2018)

### Genotoxicity

Omethoate causes a variety of health effects, especially the damage of chromosome DNA (Wang *et al.* 2019).

Long-term exposure to organophosphorus is closely related to human tumorigenesis and genetic damage (Timoroglu *et al.* 2012; Weichenthal *et al.*, 2012).

## Food safety issues

**High food safety concern.** Omethoate residues have been detected in vegetables, fruits, grains and tea (Hao *et al.*, 2011; Pan *et al.*, 2015; Zhang *et al.*, 2014). Omethoate has been reported in French beans, kales, spinach and tomatoes from peri-urban areas of Nairobi. Some of the samples exceeded the EU MRL (Omwenga *et al.*, 2020). Omethoate in tomatoes from Murang'a and Kiambu counties in Kenya were below the EU MRL (Kimpkemboi *et al.*, 2020). Omethoate levels exceeding the EU MRL were reported in sweet peppers from Khartoum (Azhari *et al.*, 2019).

## Environmental toxicity and environmental behavior of concern

This compound is currently on the list of "Priority Monitoring Pesticides" published by the Ministry of Environmental Protection of the People's Republic of China due to its toxic effects on non-target organisms after application (Pan *et al.*, 2015)

Omethoate is non-volatile, water soluble, and not mobile in soil. It will not accumulate in the soil or water or cause long term problems.

**High bee toxicity:** There is limited data available but as this is an organophosphate, it needs to be used cautiously (Sanchez-Bayo and Goka, 2014).

**Medium aquatic toxicity:** A study shows that in combination with other chemicals it can impact aquatic invertebrates (Anderson and Zhu, 2004).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Neurotoxin
- Carcinogenic potential
- Mutagenic
- Food safety concern

## References

- Anderson, T.D. and Zhu, K.Y., 2004. Synergistic and antagonistic effects of atrazine on the toxicity of organophosphorodithioate and organophosphorothioate insecticides to *Chironomus tentans* (Diptera: Chironomidae). *Pesticide Biochemistry and Physiology*, 80(1), pp.54-64. California Department of Pesticide Regulation. 2005 to 2007. Pesticide use report data. [www.cdpr.ca.gov/docs/pur/purmain.htm](http://www.cdpr.ca.gov/docs/pur/purmain.htm).
- Azhari O.A. *et al.* (2-19). Pesticides Residues in Samples of Sweet Peppers (*Capsicum annum*) from Khartoum State, Sudan. *EC Pharmacology and Toxicology* 7.7, 568-576.
- Duan, X., Yang, Y., Wang, S., Feng, X., Wang, T., Wang, P., Liu, S., Li, L., Li, G., Yao, W., Cui, L., Wang, W., (2017a). Cross-sectional associations between genetic polymorphisms in metabolic enzymes and longer leukocyte telomere length induced by omethoate. *Oncotarget* 8, 80638–80644.
- Hao, J., Wuyundalai, Liu, H., Chen, T., Zhou, Y., Su, Y.C., Li, L., (2011). Reduction of pesticide residues on fresh vegetables with electrolyzed water treatment. *J. Food Sci.* 76, C520–524.
- Kenyan Organic Agricultural Network (KOAN). 2020. Pesticide use in Kirinyaga and Murang'a Counties. <https://www.koan.co.ke/>
- Kipkemoi E., Andayi W.A., Njagi E.C., Ptoton B. (2020). Analysis of Pesticide Residues in Tomatoes and French Beans from Murang'a and Kiambu Counties, Kenya. *European Journal of Nutrition & Food Safety*, Page 121-132
- Omwenga, I., Kanja, L., Zomer, P., Louisse, J., Rietjens, I. M. C. M., & Mol, H. (2020). Organophosphate and carbamate pesticide residues and accompanying risks in commonly consumed vegetables in Kenya. *Food Additives & Contaminants: Part B*, 1–11. <https://doi.org/10.1080/19393210.2020.1861661>
- Pan, R., Chen, H.P., Zhang, M.L., Wang, Q.H., Jiang, Y., Liu, X., (2015). Dissipation pattern, processing factors, and safety evaluation for dimethoate and its metabolite (Omethoate) in tea (*Camellia sinensis*). *PLoS One* 10, e0138309.
- Qiao, J., Rong, L., Wang, Z., Zhang, M., (2017). Involvement of Akt/GSK3 $\beta$ /CREB signaling pathway on chronic omethoate induced depressive-like behavior and improvement effects of combined lithium chloride and astaxanthin treatment. *Neurosci. Lett.* 649, 55–61.
- Rong, L., Ding, K., Zhang, M., Guo, Y., (2015). Neuregulin1 $\beta$  improves cognitive dysfunction and up-regulates expression of p-ERK1/2 in rats with chronic omethoate poisoning. *Behav. Brain Funct.: BBF* 11, 5.
- Sanchez-Bayo, F. and Goka, K., 2014. Pesticide residues and bees—a risk assessment. *PloS one*, 9(4), p.e94482.
- Sieke, C., Michalski, B., Kuhl, T., (2018). Probabilistic dietary risk assessment of pesticide residues in foods for the German population based on food monitoring data from 2009 to 2014. *J. Expo. Sci. Environ. Epidemiol.* 28, 46–54.
- Timoroglu, Ilknur *et al.*, (2012). “Assessment of the Genotoxic Effects of Organophosphorus Insecticides Phorate and Trichlorfon in Human Lymphocytes.” *Environmental Ecotoxicology* 29: 577–87.
- Wang, Wei *et al.*, (2019). “Ecotoxicology and Environmental Safety Association of Genetic Polymorphisms of MiR-145 Gene with Telomere Length in Omethoate-Exposed Workers.” *Ecotoxicology and Environmental Safety* 172: 82–88. <https://doi.org/10.1016/j.ecoenv.2019.01.023>.
- Wang, Y., Li, Y.L., Meng, F.Z., Hou, B.L., Zhuang, C.N., Xiong, S.H., Ren, S.P., (2018). Effects of omethoate on liver insulin signaling in mice. *Biomed. Environ. Sci.*: BES 31, 627–631.
- Weichenthal S, Moase C, Chan P., (2010). A review of pesticide exposure and cancer incidence in the Agricultural Health Study cohort. *Environ Health Perspect.* 118(8):1117-25. doi: 10.1289/ehp.0901731.
- Weichenthal, S., Moase, C., & Chan, P. (2012). A Review of Pesticide Exposure and Cancer Incidence in the Agricultural Health Study Cohort. *Oncotarget* 7, 47966–47974. 17: 255–70.
- Zhang, Y., Ren, M., Li, J., Wei, Q., Ren, Z., Lv, J., Niu, F., Ren, S., (2014). Does omethoate have the potential to cause insulin resistance? *Environ. Toxicol. Pharmacol.* 37, 284–290.

## Imidacloprid

Imidacloprid is a neonicotinoid insecticide. It is registered in **42 products** to control a variety of insect pests on various crops. Farmers use it regularly on a wide range of crops, including coffee, cabbage, kale, maize, tomatoes, French beans, chillies, sweet potatoes, coriander, melon, spinach and beans (KOAN, 2020). Over the past decade, the EU has been tightening regulations on neonicotinoid insecticides in response to an increasingly strong body of research suggesting they are lethal for pollinators such as bees. In 2018, the EU banned the use of three neonicotinoids - imidacloprid, thiamethoxam and clothianidin. There are an increasing number of studies that show exposure to neonicotinoids poses potential risk to mammals and even humans.



















### General aspects

#### Registered products containing Imidacloprid

Agrispark 300 SC  
 Allez 200SC  
 Amigo GT 275 FS  
 Bamako WDG  
 Bellamid 600 FS  
 Buffalo 100 OD  
 Click 200 SL  
 Concord 20 SL  
 Confidor 200 SL  
 Confidor 70 WG  
 Dimiprid 200SL  
 EABCL vital 350 SC  
 Elgold 70 WDG  
 Emerald 200 SL  
 Emerald Gold 700WP  
 Fortune  
 Galil 300SC  
 Gaucho FS 350  
 Grizly 175/30 SC  
 Imaxi 200SC  
 Imidacel 200 SL  
 Imidaflo 52 FS  
 Imidagold  
 Imigo 600 FS  
 Insemida 200 SL  
 Kohinor 200 SL  
 Loyalty 700WDG  
 Metro 200SC  
 Monceren GT 390 FS  
 Murcloprid  
 Nuprid 200 SC  
 Ovados 300 SC  
 Protreat  
 Raxil Super 375  
 Seed plus 30WS  
 Seed power 250 FS  
 Seed Pro 30 WS  
 Septer 200SL  
 Shield 600 FS  
 Tata mida  
 Thunder OD 145  
 Warrant 200 SL

#### Manufacturing companies

Adama Makhteshim Ltd, Israel  
 Anhui Fengle Agrochemical Co Ltd, China  
 Bayer AG Germany, Leverkusen, Germany

<b>Manufacturing companies</b>	<p> Bayer AG Germany, Taminco, Belgium  Bayer Crop Science, Germany / Cheminova AS, Denmark.  Jiangsu Yangnong Chemical Group Co., Ltd, China.  Beijing Yoloo Bio-Technology Co., Ltd. China  East African Business Company  Excel Crop Care, India  Hailir Pesticides and Chemical Group Co. Ltd  Hubei Sanonda International / Handelsgesellscafe Detlef Von Appen mbH (DVA).  Meghmani Organics Ltd., India.  Nanjing Aijing Chemical Co., Ltd, China  Ningbo Sunjoy Agrosience Co, China  Nufarm S.A.S., France  Rallis Ltd., India.  Rotam Agrochemical Co. Ltd, Hong Kong.  Rotam Ltd., Hong Kong..  Shandong United Pesticide Industry Co. Ltd., China  Sichuan Jiadeli Technical Development Co Ltd, China  Sineria China Chemical Ltd China  Topsen Goldchance Fluence, China/ Sineria Industries Ltd, Cyprus  UPL Limited India </p>
<b>HHP</b>	Yes
<b>Withdrawn in Europe</b>	Yes
<b>Crops treated</b>	French beans, Maize, Citrus, Snow peas, Cabbages,
<b>Pest</b>	Aphids, Whiteflies, Thrips, Bean flies, Beetles, Leaf miners
<b>Alternatives*</b>	<p>Fortune, Magneto, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin), Pethrin, Pyagro, Pyeneem Oxymatrine products: Peril, Levo</p> <p>Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur</p> <p>Oxymatrine, pyrethroids</p>
<b>Human Health**</b>	
<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  
<b>Environmental Health**</b>	
<b>Bee Toxicity</b>	  



**Fish Toxicity****Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Imidacloprid is a neonicotinoid insecticide. Though it is considered less toxic to human beings when compared to the highly toxic organophosphates, it can lead to potentially life threatening complications and acute poisoning with these compounds that may be fatal in large ingestion. It causes abdominal discomfort, vomiting (Kumar, Verma, and Kumar 2013; Mundhe *et al.* 2017), drowsiness, dizziness, disorientation, and fever respiratory failure and reduced level of consciousness are the most serious but uncommon complications (Kumar, Verma, and Kumar 2013). More and more studies show exposure to neonicotinoids pose potential risk to mammals and even humans.

Exposure to imidacloprid leads to severe respiratory failure and a drop in consciousness, induces lymphocyte apoptosis (Tao *et al* 2019; Želježi, *et al.*, 2016; Kumar *et al* 2013; Lv *et al* 2020).

### Neurotoxicity

As the blood-brain barrier in vertebrates blocks access of imidacloprid to the central nervous system, neuro toxicity is reduced (Sheets, 2001). However, it is suggested that it affects developing mammalian nervous systems as it occurs with nicotine (Kimura-Kuroda *et al.*, 2012).

### Hepatotoxicity

Rats showed reductions in body weight gain, liver damage reduced blood clotting function and platelet counts. (Eiben & Rinke 1989).

### Carcinogenicity

Rats were fed imidacloprid for 18 or 24 months at unspecified concentrations. Although signs of toxicity were noted, researchers concluded that imidacloprid showed no evidence of carcinogenic potential. (Thyssen *et al.*, 1999).

### Reproductive toxicity

Rats at the highest doses showed reduced embryo development and signs of maternal toxicity. In addition, wavy ribs were observed in the fetuses (Becker *et al.*, 1987). Reduced growth and reproductive success (Gibbons *et al.*, 2015). Negative effect on sperm and testis of rats (Ramazan *et al.*, 2012).

## Food safety issues

The National Pesticide Information Centre in the US detected imidacloprid in a range of fresh and processed fruits and vegetables. It was detected in over 80% of all bananas tested, 76% of cauliflower and 72% of spinach samples. In all cases, however, the levels detected were below the US EPA's tolerance levels. Imidacloprid was also found in 17.5% of apple sauce and 0.9% of raisin samples, although percentage of detections were greater in the fresh unprocessed fruit (Gervais *et al.*, 2010).

Significant residue levels of imidacloprid were present in tomatoes in Kirinyaga County (Momanyi *et al.*, 2019). Imidacloprid has been reported in French beans, tomatoes and kales from Meru (Marete *et al.*, 2020) in tomatoes grown in Mwea (Nakhungu *et al.*, 2021) in French beans from Murang'a and Kiambu counties (Kipkemai *et al.*,

2020), tomatoes from Machakos and kale from Kiambu (unpublished data, Route to Food, 2020) and in honey (Mulati *et al.*, 2018). However, the concentrations were below the EU and Codex MRLs.

## Environmental toxicity and environmental behavior of concern

Imidacloprid is highly soluble, non-volatile and persistent in soil. It is moderately mobile and has a low risk of bio-accumulation (Lewis *et al.*, 2016).

Neonicotinoids are a group of active ingredients that all have a negative impact on pollinators. To this group also belong thiamethoxam, fipronil and acetamiprid.

**High bee toxicity:** The toxicity and sub-lethal effects of imidacloprid on bees are well established (Feltham *et al.*, 2014). The active ingredient has also been found to repel pollinators from crops in field-level concentrations, which could impact yields on pollinator-dependent crops (Easton and Goulson, 2013). Imidacloprid affects the individual immunity of bees, resulting in reduced disease resistance (Brandt *et al.*, 2016; DiBartolomeis, 2019; Reid *et al.*, 2020; Dively *et al.*, 2015). Only honeybees and bumblebees have been investigated. No information is available of susceptibility of other pollinating taxa such as hoverflies or butterflies. Exposure to sub-lethal doses of neonicotinoids is known to reduce learning, foraging ability and homing ability in both honeybees and bumblebees (Yang *et al.* 2008; Han *et al.* 2010; Mommaerts *et al.* 2010; Henry *et al.*, 2012), which has major impacts on colony success. Negative effects have been shown on predatory ground beetles and parasitoid wasps (Fossen, 2006).

**Medium to high aquatic toxicity:** Moderately to highly toxic to most aquatic species (Roessink *et al.*, 2013, Vijver and van den Brink, 2014). It is suggested that tropical species are more sensitive to imidacloprid than temperate species from Europe (Sumon *et al.*, 2018). It causes deformity and reduces growth in aquatic organisms (Vignet *et al.* 2019; Lukaszewicz *et al.*, 2019; Vieira *et al.*, 2018).

**Medium to high bird toxicity:** High toxicity to birds (Tomlin, 1989). Declines in insectivorous birds and seed eating birds are associated with imidacloprid exposure (Hallmann *et al.*, 2014).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**. Proposed withdrawal in Kenya should be based on:

- Effect on reproduction, possibly neurotoxic
- High bee toxicity
- High aquatic toxicity
- High bird toxicity
- High persistence in soil

## References




























- Becker, H., Vogel, W., Terrier, C., (1988) Embryotoxicity study (including teratogenicity) with NTN 33893 technical in the rat. Unpublished Report no. R 4582, 1988, submitted to WHO by Bayer AG, Mannheim, Germany. INCHEM Toxicological Evaluations: Imidacloprid; International Programme on Chemical Safety, World Health Organization: Geneva, Switzerland, 1988a.
- Brandt, A.; Gorenflo, A.; Siede, R.; Meixner, M.; Büchler, R., (2016). The neonicotinoids thiacloprid, imidacloprid, and clothianidin affect the immunocompetence of honey bees (*Apis mellifera* L.). *J. Insect Physiol.* 2016, 86, 40–47.
- DiBartolomeis, M.; Kegley, S.; Mineau, P.; Radford, R.; Klein, K, (2019). An assessment of acute insecticide toxicity loading (AITL) of chemical pesticides used on agricultural land in the United States. *PLoS ONE* 2019, 14, e0220029.
- Dively *et al.*, (2015). Assessment of Chronic Sublethal Effects of Imidacloprid on Honey Bee Colony Health. *PloS one*, 10(3), e0118748. doi:10.1371/journal.pone.0118748.
- Draft list, (2007). Initial pesticide active ingredients and pesticide inerts to be considered for screening under the Federal Food, Drug, and Cosmetic Act. Fed, 72 (116), 33486-33503
- Easton, A.H. and Goulson, D., 2013. The neonicotinoid insecticide imidacloprid repels pollinating flies and beetles at field-realistic concentrations. *PLoS One*, 8(1), p.e54819.
- Eiben, R.; Rinke. (1986) M. NTN 33893: Subchronic toxicity study on Wistar-rats (administration in the feed for 96 days). Unpublished Report no. 18187, 1989, submitted to WHO by Bayer AG, Mannheim, Germany. INCHEM Toxicological Evaluations: Imidacloprid; International Programme on Chemical Safety, World Health Organization: Geneva, Switzerland, 1989
- Feltham H, Park K, Goulson D. (2014). Field realistic doses of pesticide imidacloprid reduce bumblebee pollen foraging efficiency. *Ecotoxicology*. Apr;23(3):317-23. <https://doi.org/10.1007/s10646-014-1189-7>
- Fossen, M., (2006). Environmental Fate of Imidacloprid; California Department of Pesticide Regulation, Environmental Monitoring: Sacramento, CA,
- Gervais, J. A.; Luukinen, B.; Buhl, K.; Stone, D. (2010). Imidacloprid Technical Fact Sheet; National Pesticide Information Center, Oregon State University Extension Services. <http://npic.orst.edu/factsheets/archive/imidacloprid.html>
- Gibbons, D., Morrissey, C. & Mineau, P. A (2015). Review of the direct and indirect effects of neonicotinoids and fipronil on vertebrate wildlife. *Environ Sci Pollut Res* 22, 103–118 <https://doi.org/10.1007/s11356-014-3180-5>
- Hallmann, C., Foppen, R., van Turnhout, C. *et al.* (2014). Declines in insectivorous birds are associated with high neonicotinoid concentrations. *Nature* 511, 341–343 <https://doi.org/10.1038/nature13531>
- Han, W.; Tian, Y.; Shen, X., (2018) Human exposure to neonicotinoid insecticides and the evaluation of their potential toxicity: An overview. *Chem. Eng. J.* 2018, 192, 59–65.
- Henry, Mickaël & Béguin, Maxime & Requier, Fabrice & Rollin, Orianne & Odoux, Jean-François & Aupinel, Pierrick & Aptel, Jean & Tchamitchian, Sylvie & Decourtye, Axel. (2012). A Common Pesticide Decreases Foraging Success and Survival in Honey Bees. *Science* (New York, N.Y.). 336. 348-500. <https://doi.org/10.1126/science.1215039>
- Kimura-Kuroda J, Komuta Y, Kuroda Y, Hayashi M, Kawano H (2012) Nicotine-Like Effects of the Neonicotinoid Insecticides Acetamiprid and Imidacloprid on Cerebellar Neurons from Neonatal Rats. *Plos One* 7(2): <https://doi.org/10.1371/journal.pone.0032432>
- Kipkemoi E., Andayi W.A, Njagi E.C., Ptoton B. (2020). Analysis of Pesticide Residues in Tomatoes and French Beans from Murang'a and Kiambu Counties, Kenya. *European Journal of Nutrition & Food Safety*, Page 121-132

- Kizar Ahmed Sumon, Afifat Khanam Ritika, Edwin T.H.M. Peeters, Harunur Rashid, Roel H. Bosma, Md. Shahidur Rahman, Mst. Kaniz Fatema, Paul J. Van den Brink. (2018). Effects of imidacloprid on the ecology of sub-tropical freshwater microcosms. *Environmental Pollution*, 236. 432-441. ISSN 0269-7491 <https://doi.org/10.1016/j.envpol.2018.01.102>
- KOAN-Kenyan Organic Agricultural Network, 2020. Pesticide use in Kirinyaga and Murang'a county. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf)
- Kumar, A.; Verma, A.; Kumar, A. Accidental human poisoning with a neonicotinoid insecticide, imidacloprid: A rare case report from rural India with a brief review of literature. *Egypt. J. Forensic Sci.* 2013, 3, 123–126.
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016) An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- Lukaszewicz, G., Iturburu, F. G., Garanzini, D. S., Menone, M. L., & Pflugmacher, S. (2019). Imidacloprid modifies the mitotic kinetics and causes both aneugenic and clastogenic effects in the macrophyte *Bidens laevis* L. *Heliyon*, 5(7). <https://doi.org/10.1016/j.heliyon.2019.e02118>
- Lv, Y., Bing, Q., Lv, Z., Xue, J., Li, S., Han, B., Yang, Q., Wang, X., Zhang, Z., (2020). Imidacloprid-induced liver fibrosis in quails via activation of the TGF- $\beta$ 1/Smad pathway. *Sci. Total Environ*, 705, 135915.
- Marete, G.M., Shikuku, V.O., Lalah, J.O. *et al.*, (2020). Occurrence of pesticides residues in French beans, tomatoes, and kale in Kenya, and their human health risk indicators. *Environ Monit Assess* 192, 692 <https://doi.org/10.1007/s10661-020-08662-y>
- Momanyi, V. N.; Kerala, M., Abong'o, D. J., Warutere, P. N., (2019). Types and Classification of Pesticides Used on Tomatoes Grown in Mwea Irrigation Scheme, Kirinyaga County, Kenya
- Mommaerts V, Reynders S, Boulet J, Besard L, Sterk G, Smagghe G .(2010). Risk assessment for side-effects of neonicotinoids against bumblebees with and without impairing foraging behavior. *Ecotoxicology*. Jan;19(1):207-15. <https://doi.org/10.1007/s10646-009-0406-2>
- Mulati P., Kitur E., Taracha C., Kurgat J., Raina S., Irungu J., (2018). Evaluation of Neonicotinoid Residues in Hive Products from Selected Counties in Kenya. *J Environ Anal Toxicol.*, 8:4
- Mundhe, S. A., Birajdar, S. V., Chavan, S. S., & Pawar, N. R. (2017). Imidacloprid Poisoning: An Emerging Cause of Potentially Fatal Poisoning. *Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine*, 21(11), 786–788. [https://doi.org/10.4103/ijccm.IJCCM\\_152\\_17](https://doi.org/10.4103/ijccm.IJCCM_152_17)
- Nakhungu M., Keraka N., Abong'o A., Warutere N., Peterson N., (2021). Pesticide Residues on Tomatoes Grown and Consumed in Mwea Irrigation Scheme, Kirinyaga County, Kenya. *Asian Journal of Agricultural and Horticultural Research*, Page 1-11
- Ramazan B., Naziroğlu M, Türk G, Yılmaz Ö, Kuloğlu T, Etem E, Baydas G. (2012) Insecticide imidacloprid induces morphological and DNA damage through oxidative toxicity on the reproductive organs of developing male rats. *Cell Biochem Funct*. Aug;30(6):492-9. <https://doi.org/10.1002/cbf.2826>.
- Reid, R.J.; Troczka, B.J.; Kor, L.; Randall, E.; Williamson, M.S.; Field, L.M.; Nauen, R.; Bass, C.; Emyr Davies, T.G., (2020). Assessing the acute toxicity of insecticides to the buff-tailed bumblebee (*Bombus terrestris* audax). *Pestic. Biochem. Phys*, 166, 104562
- Roessink, Ivo & Merga, Lemessa & Zweers, A.j & Van den Brink, Paul. (2013). The neonicotinoid imidacloprid shows high chronic toxicity to mayfly nymphs. *Environmental toxicology and chemistry / SETAC*. 32. <https://doi.org/10.1002/etc.2201>
- Sheets, L. P., (2001). *Imidacloprid: A Neonicotinid Insecticide. Handbook of Pesticide Toxicology*, 2nd ed.; Krieger, R. I., Ed.; Academic Press: San Diego, CA, 2001; Vol. 2, Chapter 54, pp 1123-1130
- Tao, Y., Phung, D., Dong, F., Xu, J., Liu, X.; Wu, X.; Liu, Q.; He, M.; Pan, X.; Li, R.; *et al.*, (2019). Urinary monitoring of neonicotinoid imidacloprid exposure to pesticide applicators. *Sci. Total Environ*, 669, 721–728.

- Thyssen, J.; Machemer, L., (1999). Imidacloprid: *Toxicology and Metabolism. Nicotinoid Insecticides and the Nicotinic Acetylcholine Receptor*; Yamamoto, I.; Casida, J. E., Eds.; Springer-Verlag: Tokyo, Chapter 9, pp 213-222
- Tomlin, C. D. S., (2006). The Pesticide Manual, A World Compendium, 14th ed.; British Crop Protection Council: Surry, England, 2006; pp 598-59
- Vieira, C.E.D.; Pérez, M.R.; Acayaba, R.D.A.; Raimundo, C.C.M.; dos Reis Martinez, C.B., (2018). DNA damage and oxidative stress induced by imidacloprid exposure in different tissues of the Neotropical fish *Prochilodus lineatus*. *Chemosphere*, 195, 125–134.
- Vignet, C.; Cappello, T.; Fu, Q.; Lajoie, K.; De Marco, G.; Clérandeau, C.; Mottaz, H.; Maisano, M.; Hollender, J.; Schirmer, K.; *et al.*, (2019). Imidacloprid induces adverse effects on fish early life stages that are more severe in Japanese medaka (*Oryzias latipes*) than in zebrafish (*Danio rerio*). *Chemosphere*, 225, 470–478.
- Vijver MG, van den Brink PJ (2014) Macro-Invertebrate Decline in Surface Water Polluted with Imidacloprid: A Rebuttal and Some New Analyses. *Plos One* 9(2): e89837.
- Želježić, D.; Mladinić, M.; Žunec, S.; Luci'c Vrdoljak, A.; Kašuba, V.; Tariba, B.; Živković, T.; Marjanović, A.M.; Pavićić, I.; Milić, M.; *et al.*, (2016). Cytotoxic, genotoxic and biochemical markers of insecticide toxicity evaluated in human peripheral blood lymphocytes and an HepG2 cell line. *Food Chem. Toxicol.*, 96, 90–106.

## Thiacloprid

Thiacloprid is an insecticide of neonicotinoid class. It acts by disrupting the insect's nervous system by stimulating nicotinic acetylcholine receptors. It is registered in **1 product** to control sucking and chewing insect pests on chillies, eggplant, tomatoes and onions.

General aspects	
Registered products containing Thiacloprid	Calypso SC 480
Manufacturing companies	Bayer AG Germany.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Chillies, Eggplants, Tomatoes, Onions
Pest	Aphids, Whiteflies, Thrips, Mealybugs, Spidermites, Caterpillars
Alternatives*	Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Pyriproxifen, Sulphur Oxymatrine, pyrethroids
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high



## Human health effects of concern

Thiacloprid has high, low and moderate acute toxicity when exposed through by the oral, dermal and inhalation routes respectively (European Commission, 2003; European Commission, 2012; EFSA PPR Panel, 2012; EFSA, 2014c; European Commission, 2015; ECHA, 2017). It is a skin and eye irritant and a possible liver and thyroid irritant (Lewis *et al.*, 2016). This pesticide has negative health effects especially when combined with tebuconazole. It is known for acute toxicity when swallowed (Balaban, 2010).

### Genotoxicity/carcinogenicity

Thiacloprid significantly decreases mitotic index, proliferation index, and nuclear division index in the absence and presence of an exogenous metabolic activator in human peripheral blood lymphocytes (Kocaman *et al.*, 2014). It also significantly increases the formation of chromosome aberrations, sister chromatid exchanges and micronucleus in the absence and presence of an exogenous metabolic activator in human peripheral blood lymphocytes (Kocaman *et al.*, 2014). Thiacloprid significantly decreases proliferation indices and increases in the frequency of DNA damage as detected in bovine peripheral lymphocytes (Galdíková *et al.*, 2015). Thiacloprid also decreases cell viability in dose-dependent manner and induces DNA damage and human hepatocellular carcinoma (Sekeroglu *et al.* 2014).

## Food safety issues

Thiacloprid residues have been reported in onions (Dasenaki *et al.*, 2016) and in tomato, okra, cauliflower, guava, and citrus from Pakistan (Akram *et al.*, 2017). No data was found regarding residue levels in food products in Kenyan markets.

## Environmental toxicity and environmental behavior of concern

Thiacloprid shows low persistence in soils under aerobic conditions. It has low potential for groundwater exposure (EFSA, 2019)

**High bee toxicity:** Many studies are relevant as part of wider research available on the impacts of the neonicotinoids (Brandt *et al.*, 2016; deOliveria *et al.*, 2019). Specifically, thiacloprid shows impacts on bees, including on their learning and foraging behavior (Ellis *et al.*, 2017). It has also been shown to impact soil invertebrates (eSilva *et al.*, 2017). There is evidence of declining insectivorous bird populations as a result of insect population decline (Balaban, 2010).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Likelihood of being a carcinogen
- High bee toxicity


















## References

- Akram, S., Sultana, B., Asi, M., Mushtaq, M., (2017). Salting-out-assisted liquid–liquid extraction and reverse-phase high-performance liquid chromatographic monitoring of thiacloprid in fruits and vegetables. *Separation Science and Technology*, 53, 1–9. <https://doi.org/10.1080/01496395.2017.1417317>
- Balaban, A. T. (2010). ChemInform Abstract: Aromaticity of Six-Membered Rings with One Heteroatom. *ChemInform*, 41(15). <https://doi.org/10.1002/chin.201015222>
- Dasenaki, M., Bletsou, A., Hanafi, A., Thomaidis, N. (2016). Liquid chromatography-tandem mass spectrometric methods for the determination of spinosad, thiacloprid and pyridalyl in spring onions and estimation of their pre-harvest interval values. *Food Chemistry*, 213,
- De Oliveira Jacob, C.R., Zanardi, O.Z., Malaquias, J.B., Silva, C.A.S. and Yamamoto, P.T., (2019). The impact of four widely used neonicotinoid insecticides on *Tetragonisca angustula* (Latreille) (Hymenoptera: Apidae). *Chemosphere*, 224, pp.65-70.
- De Silva, C.D.L., Brennan, N., Brouwer, J.M., Commandeur, D., Verweij, R.A. and van Gestel, C.A., (2017). Comparative toxicity of imidacloprid and thiacloprid to different species of soil invertebrates. *Ecotoxicology*, 26(4), pp.555-564.
- ECHA (European Chemicals Agency), (2017). Guidance on the Application of the CLP Criteria; Guidance to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures. Reference: ECHA-17-G-21-EN; ISBN: 978-92-9020-050-5. <https://echa.europa.eu/guidance-documents/guidance-on-clp>.
- EFSA (European Food Safety Authority), (2014). Guidance on the assessment of exposure of operators, workers, residents and bystanders in risk assessment for plant protection products. *EFSA Journal*, 12(10):3874, 55 pp. <https://doi.org/10.2903/j.efsa.2014.3874>
- EFSA PPR Panel (EFSA Panel on Plant Protection Products and their Residues), (2012). Guidance on dermal absorption. *EFSA Journal*, 10(4):2665, 30 pp. <https://doi.org/10.2903/j.efsa.2012.2665>.
- EFSA, Abdourahime, H., Anastassiadou, M., Arena, M., Auteri, D., Barmaz, S., & Villamar-Bouza, L. (2019). Peer review of the pesticide risk assessment of the active substance thiacloprid. *EFSA journal*, 17(3), e05595.
- Ellis, C., Park, K.J., Whitehorn, P., David, A. and Goulson, D., (2017). The neonicotinoid insecticide thiacloprid impacts upon bumblebee colony development under field conditions. *Environmental science & technology*, 51(3), pp.1727-1732.
- European Commission, (2003). Guidance Document on Assessment of the Relevance of Metabolites in Ground-water of Substances Regulated under Council Directive 91/414/EEC. SANCO/221/2000-rev.
- European Commission, (2012). Guidance document on the assessment of the equivalence of technical materials of substances regulated under Regulation (EC) No 1107/2009. SANCO/10597/2003.
- European Commission, (2015). Draft Technical Guidance Document on assessment of negligible exposure of an active substance in a plant protection product under realistic conditions of use (points 3.6.3 to 3.6.5, and 3.8.2 of Annex II of Regulation (EC) No 1107/2009), SANCO/2014/12096, November 2015.
- Galdíková M, Šíviková K, Holečková B, Dianovský J, Drážovská M, Schwarzbacherová V. (2015). The effect of thiacloprid formulation on DNA/chromosome damage and changes in GST activity in bovine peripheral lymphocytes. *J Environ Sci Health B*;50(10):698-707. doi: 10.1080/03601234.2015.1048102.
- Hallmann, C. A., Foppen, R. P. B., Van Turnhout, C. A. M., De Kroon, H. & Jongejans, E. (2014). Declines in insectivorous birds are associated with high neonicotinoid concentrations. *Nature* 511, 341–343 <https://echa.europa.eu/guidance-documents/guidance-on-clp>

- Kocaman AY, Rencüzoğulları E, Topaktaş M. (2014). In vitro investigation of the genotoxic and cytotoxic effects of thiacloprid in cultured human peripheral blood lymphocytes. *Environ Toxicol.* 29(6):631-41. doi: 10.1002/tox.21790.
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A., (2016) An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242
- Sekeroglu V, Atli S, ekerog̃lu Z and Demirhan ES., (2014) Effects of commercial formulations of deltamethrin and/or thiacloprid on thyroid hormone levels in rat serum. *Toxicology and Industrial Health* 30: 40–46.

## Malathion

Malathion is a broad-spectrum insecticide. It is registered in **13 products** to control a wide range of sucking and chewing insects on various crops. Farmers are using malathion on cabbage, maize, kale, tomatoes, avocados, sweet potatoes, cucumber, rice, beans and melons (KOAN, 2020).

General aspects	
Registered products containing Malathion	Dera Blue Cross Dera Blue Cross Dust Dera Malathion 50 EC Fedothion 50 EC Fyfanon 50EC Magic 50 EC Nova Super Blue Cross Nova Super Blue Cross Dust Oshothion 50 EC Permal Dust Skana Super Grain Dust Super Blue Cross Dust Super Malper Dust
Manufacturing companies	Bharat Insecticide Ltd., India Cheminova AS, Denmark Dera Chemical Industries (K) Ltd. Sulphur Mills India Sulphur Mills, India. / Osho Chemical Industries Ltd.
HHP	Yes
Withdrawn in Europe	No
Crops treated	Kales, Beans, Tomatoes, French beans, Grains, Cabbages, Avocados
Pest	Aphids, Diamond black moth, Whiteflies, Russet mites, Weevils, Larger grain borer, Caterpillars, Fruit flies
Alternatives*	Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Pyriproxifen, Sulphur Oxymatrine, pyrethroids
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  

**Environmental Health\*\*****Bee Toxicity****Fish Toxicity****Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern**

Malathion belongs to the class of organothiophosphate acaricides. It is moderately toxic by the oral route. It is not acutely toxic through inhalation. It is not irritant to the skin or eye but it is a skin sensitizer. Malathion exposure can cause muscular weakness, cramping or twitching, ataxia, hepatotoxicity, and paralysis (Alp *et al.*, 2012; Nain *et al.*, 2011; Mostafalou *et al.*, 2012). Generally it has low to moderate toxicity, but its metabolites are highly toxic. Malaoxon is considered to be 22 times more toxic than the parent malathion (Gervais *et al.*, 2009).

Malathion exerts toxic action by binding to acetylcholinesterase enzyme and inhibiting its activity, leading to accumulation of acetylcholine in synaptic junctions, which in turn results in overstimulation of cholinergic, muscarinic, and nicotinic receptors, and subsequent induction of adverse biologic effect. Depending on the level of exposure, several signs and symptoms of toxicity include numbness, tingling sensation, headache, dizziness, difficulty breathing, weakness, and irritation of skin, exacerbation of asthma, abdominal cramps and death.

**Neurotoxicity**

It is a neurotoxin and an acetylcholinesterase inhibitor (EPSA, 2019). Its poisonous impact is caused by the buildup of acetylcholine as a result of the inhibition of acetylcholinesterase (Venkataraman and Sandhya 2013; Pezzoli *et al.*, 2015; Selmi *et al.*, 2012). Malathion has been linked to potential neurotoxic effects on nursing children (Koutros *et al.*, 2019; Hohenadel *et al.*, 2011; Stella *et al.*, 2019; Pahwa *et al.* 2012; Salama *et al.*, 2015).

**Endocrine disrupter**

Malathion is identified as an endocrine disruptor, which can disturb hormone levels through different mechanisms including inhibition of hormonal secretion (Mnif *et al.* 2011; Geng *et al.* 2015b; Schang *et al.* 2016). It is also a possible adrenal gland, liver and thyroid toxicant (Lewis *et al.*, 2016).

**Carcinogenicity**

Malathion was classified as “probably carcinogenic to humans” (Group 2A) by the International Agency for Research on Cancer (IARC) (Guyton *et al.* 2015). It was found to increase hepatocellular adenoma and carcinoma in mice and rats (Guyton *et al.* 2015). There is evidence of a positive correlation between malathion exposure and thyroid cancer (Brasil *et al.*, 2018). Malathion has been linked to an increased risk of non-lymphoma Hodgkin’s (Koutros *et al.*, 2019; Hohenadel *et al.*, 2011; Stella *et al.* 2019; Pahwa *et al.* 2012). Occupational use is associated with prostate cancer (Band *et al.* 2011; Koutros *et al.* 2012).

**Genotoxicity**

Genotoxicity, oxidative stress, inflammation, receptor-mediated effects and cell proliferation or death can all be associated with malathion exposure (Guyton *et al.*, 2015). Malathion also causes DNA and chromosomal damage (Guyton *et al.*, 2015).

### Neurotoxicity

There is a high correlation between high-level malathion exposure and neurological or neuropsychological impairments (Naughton and Terry 2018; Glass *et al.* 2018). Neurological and psychological effects of organophosphates can be associated with either acute or chronic exposure and may include motor dysfunction and extrapyramidal symptoms, psychosis, anxiety, depression, as well as defects in attention, memory, problem-solving, cognition, and delayed polyneuropathy (Pereira *et al.* 2014; Naughton and Terry 2018).

### Hepatotoxicity

Malathion causes hepatocellular damage in liver tissue and increases the activity of liver enzymes. Malathion hepatotoxicity was even reported in rat pups exposed to Malathion through lactation (Selmi *et al.* 2015).

### Nephrotoxicity

Associated with acute renal injury and nephrotic syndrome in a man, 15 days after malathion inhalation, associated with proteinuria, abnormality in serum creatinine, and glomerular and tubular damage (Yokota *et al.* 2017).

### Reproductive toxicity

Malathion induces reproductive toxicity in animals and humans and plays a role in mediating infertility (Runkle *et al.* 2017).

## Food safety issues

The widespread use of malathion in agriculture for different purposes in the world has caused residues on food such as fruits and vegetables. Grapes collected from different vineyards in three different Aegean regions showed malathion residues (Voigt *et al.*, 2014). Turgut *et al.* (2011) suggested that preharvest intervals should be discussed. Malathion was among four pesticides found in significant levels as pesticide residues on tomatoes grown and consumed in Mwea Irrigation Scheme, Kirinyaga County (Momanyi *et al.*, 2021). Malathion, beyond EU and Codex MRLs, was reported in tomatoes from Kirinyaga County in Kenya (Nakhungu *et al.*, 2021), in vegetables in Nairobi markets (Omwenga *et al.*, 2020) and in vegetables from Tanzania (Kiwango *et al.*, 2018).

## Environmental toxicity and environmental behavior of concern

It is moderately soluble in water and readily soluble in many organic solvents. It is quite volatile and has a low potential for leaching to groundwater. Malathion is not usually persistent in soil or water systems. In soil under aerobic and anaerobic conditions, malathion is degraded to MMCA, MDCA. Small amounts of malic, lactic, glycolic, succinic and tartaric acid are also produced before final mineralization to carbon dioxide. It has potential for ground water exposure.

**High bee toxicity:** Malathion is highly toxic to bees and other beneficial insects (Cabrera-Marín *et al.*, 2016). There is evidence of impacts on honeybees when used a broad spectrum application, but less impacts on insects when used in baits or more specifically (Vayssières *et al.*, 2007; Gary and Mussen, 1984).

**Medium aquatic toxicity:** Acute toxicity to aquatic organism and fish (Ahmad, 2012; Rauf, 2015; Naserabad *et al.*, 2015; Fahmy, 2012; Magar and Shaikh, 2013; Venkataraman and Sandhya Rani, 2013).

**Medium to low birds toxicity:** Malathion causes mutagenesis and gonado-toxic effects in birds (Hussain *et al.*, 2015)

## Pesticide's alternatives

Biological control methods and chemical control methods by use of Spinosad insecticide are good alternative sources for malathion (Urbaneja *et al.*, 2009). See Table above.

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Neurotoxicity
- Possible carcinogenicity
- Bee toxicity
- Food safety

## References

- Ahmad, Z., (2012). Toxicity bioassay and effects of sub-lethal exposure of malathion on biochemical composition and haematological parameters of *Clarias gariepinus*. *African Journal of Biotechnology*. 11(34), pp 8578-8585.
- Alp H, Aytekin I, Hatipoglu NK, Alp A, Ogun M., (2012). Effects of sulforophane and curcumin on oxidative stress created by acute malathion toxicity in rats. *Eur Rev Med Pharmacol Sci* 2012;16(3):144–8.
- Brasil VLM, Ramos Pinto MB, Bonan RF *et al.*, (2018) Pesticides as risk factors for head and neck cancer: a review. *J Oral Pathol Med* 47: 641–651. <https://doi.org/10.1111/jop.12701>
- Cabrera-Marín, N.V., Liedo, P. and Sánchez, D., 2016. The effect of application rate of GF-120 (Spinosad) and Malathion on the mortality of *Apis mellifera* (Hymenoptera: Apidae) foragers. *Journal of economic entomology*, 109(2), pp.515-519.
- Chai, L. K., Mohd-Tahir, N., & Bruun Hansen, H. C. (2008). Dissipation of acephate, chlorpyrifos, cypermethrin and their metabolites in a humid-tropical vegetable production system. *Pest Management Science*, 65(2), 189–196. <https://doi.org/10.1002/ps.1667>
- Fahmy, G. H., (2012). Malathion Toxicity: Effect on Some Metabolic Activities in *Oreochromis niloticus*, the Tilapia Fish. *International Journal of Bioscience, Biochemistry and Bioinformatics*, 2 (1) pp 52-55
- Gary, N.E. and Mussen, E.C., 1984. Impact of Mediterranean fruit fly malathion bait spray on honey bees. *Environmental entomology*, 13(3), pp.711-717.
- Geng X, Bo C, Han G, Shao H., (2015a). Effects of malathion on testicular spermatogenic function in rats. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi* 33:180–185
- Gervais, J. A.; Luukinen, B.; Buhl, K.; Stone, D. (2009). Malathion Technical Fact Sheet; National Pesticide Information Center, Oregon State University Extension Services. <http://npic.orst.edu/factsheets/archive/malatech.html>.
- Glass T, Dalvie MA, Holtman Z *et al.*, (2018). DNA variants and organophosphate neurotoxicity among emerging farmers in the Western Cape of South Africa. *Am J Ind Med* 61:11–20. <https://doi.org/10.1002/ajim.22790>
- Guyton KZ, Loomis D, Grosse Y *et al.*, (2015). Carcinogenicity of tetrachlorvinphos, parathion, malathion, diazinon, and glyphosate. *Lancet Oncol* 16:490–491. [https://doi.org/10.1016/S1470-2045\(15\)70134-8](https://doi.org/10.1016/S1470-2045(15)70134-8)
- Hussain R, Mahmood F, Khan A., (2015). Genotoxic and Pathological Effects of Malathion in Male Japanese Quail (*Coturnix japonica*). *Pak J Agri Sci* 2015; 52(4):1149-1156.
- IARC (2015). International Agency for Research on Cancer (IARC), Malathion 112, IARC, Lyon, France.
- Kiwango PA, Kassim N, Kimanya ME. (2018). The risk of dietary exposure to pesticide residues and its association with pesticide application practices among vegetable farmers in Arusha, Tanzania. *J Food Res*. 7(2). doi:10.5539/jfr.v7n2p86.
- KOAN-Kenyan Organic Agricultural Network, 2020. Pesticide use in Kirinyaga and Murang'a county. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf)
- Koutros, S.; Harris, S.A.; Spinelli, J.J.; Blair, A.; McLaughlin, J.R.; Zahm, S.H.; Kim, S.; Albert, P.S.; Kachuri, L.; Pahwa, M.; *et al.*, (2019). Non-Hodgkin lymphoma risk and organophosphate and carbamate insecticide use in the north American pooled project. *Environ. Int.* 2019, 127, 199–205.
- Magar, R. S. and Shaikh, A., (2013). Effect of malathion toxicity on detoxifying organ of fresh water fish *Channa punctatus*. *International journal of pharmaceutical, chemical and biological sciences*, 3(3) pp 723-728.
- Mostafalou S, Eghbal MA, Nili-Ahmadabadi A, Baeeri M, Abdollahi M., (2012). Biochemical evidence on the potential role of organophosphates in hepatic glucose metabolism toward insulin resistance through inflammatory signaling and free radical pathways. *Toxicol Ind Health* 2012;28(9):840–51.






























- Momanyi VN, Keraka MN, Abong'o AD & Warutere PN. (2021) Pesticide Residues on Tomatoes Grown and Consumed in Mwea Irrigation Scheme, Kirinyaga County, Kenya *Asian Journal of Agricultural and Horticultural Research*, Page 1-11 DOI: 10.9734/AJAHR/2021/v8i230110
- Mnif W, Hassine AIH, Bouaziz A *et al.*, (2011). Effect of endocrine disruptor pesticides: a review. *Int J Environ Res Public Health* 8: 2265–2303. <https://doi.org/10.3390/ijerph8062265>
- Naughton SX, Terry AV., (2018). Neurotoxicity in acute and repeated organophosphate exposure. *Toxicology* 408:101–112. <https://doi.org/10.1016/j.tox.2018.08.011>
- Nain S, Bour A, Chalmers C, Smits JE., (2011). Immunotoxicity and disease resistance in Japanese quail (*Coturnix coturnix japonica*) exposed to malathion. *Ecotoxicology*.20:892–900.
- Nakhungu, M. V., Margaret, N. K., Deborah, A. A., & Peterson, N. W. (2021). Pesticide Residues on Tomatoes Grown and Consumed in Mwea Irrigation Scheme, Kirinyaga County, Kenya. *Asian Journal of Agricultural and Horticultural Research*, 8(2), 1-11. <https://doi.org/10.9734/ajahr/2021/v8i230110>
- Naserabad, S.S., Mirvaghefi, A., Gerami, M.H., and Farsani, H.G., (2015). Acute Toxicity and Behavioral Changes of the Gold Fish (*Carassius auratus*) Exposed to Malathion and Hinosan. *Iranian Journal of Toxicology*, 8 (27) pp 1203- 1208
- Omwenga, I., Kanja, L., Zomer, P., Louisse, J., Rietjens, I. M. C. M., & Mol, H. (2020). Organophosphate and carbamate pesticide residues and accompanying risks in commonly consumed vegetables in Kenya. *Food Additives & Contaminants: Part B*, 1–11. <https://doi.org/10.1080/19393210.2020.1861661>
- Pereira EFR, Aracava Y, DeTolla LJ *et al* (2014) Animal models that best reproduce the clinical manifestations of human intoxication with organophosphorus compounds. *J Pharmacol Exp Ther* 350:313– 321. <https://doi.org/10.1124/jpet.114.214932>
- Pezzoli, G., & Cereda, E. (2013). Exposure to pesticides or solvents and risk of Parkinson disease. *Neurology*, 80(22), 2035-2041.
- Rauf, A., (2015). Acute toxicity and effects of malathion exposure on behavior and hematological indices in Indian carp, *Cirrhinus mrigala* (Hamilton). *International Journal of Aquatic Biology*, 3(4) pp199-207.
- Runkle J, Flocks J, Economos J, Dunlop AL (2017) A systematic review of Mancozeb as a reproductive and developmental hazard. *Environ Int* 99:29–42. <https://doi.org/10.1016/j.envint.2016.11.006>
- Schang G, Robaire B, Hales BF (2016) Organophosphate flame retardants act as endocrine-disrupting chemicals in MA-10 mouse tumor Leydig cells. *Toxicol Sci* 150:499–509. <https://doi.org/10.1093/toxsci/kfw012>
- Selmi S, El-Fazaa S, Gharbi N (2015) Oxidative stress and alteration of biochemical markers in liver and kidney by malathion in rat pups. *Toxicol Ind Health* 31:783–788. <https://doi.org/10.1177/0748233713475507>
- Selmi S., El-Fazaa S., Gharbi N., (2012). Oxidative stress and cholinesterase inhibition in plasma, erythrocyte and brain of rats' pups following lactational exposure to malathion. *Environ. Toxicol. Pharmacol.* 2012;34(3):753–760
- Turgut C., Ornek H., Cutright T.J., (2011). Determination of pesticide residues in Turkey's table grapes: the effect of integrated pest management, organic farming, and conventional farming. *Environ Monit Assess.* 173:315-323
- Urbaneja A, Chueca P, Montón H, Pascual-Ruiz S, Dembilio O, Vanaclocha P, Abad-Moyano R, Pina T, Castañera P. Chemical alternatives to malathion for controlling *Ceratitis capitata* (Diptera: Tephritidae), and their side effects on natural enemies in Spanish citrus orchards. *J Econ Entomol.* 2009 Feb;102(1):144-51. doi: 10.1603/029.102.0121.
- Vayssières, J.F., Cayol, J.P., Perrier, X. and Midgarden, D., 2007. Impact of methyl eugenol and malathion bait stations on non-target insect populations in French Guiana during an eradication program for *Bactrocera carambolae*. *Entomologia Experimentalis et Applicata*, 125(1), pp.55-62.



- Venkataraman, G.V. and Sandhya Rani, P. N., (2013). Acute toxicity and blood profile of freshwater fish, *Clarias batrachus* (Linn.) exposed to Malathion. *Journal of Academia and Industrial Research (JAIR)*, 2(3) pp 200-204
- Voight K., Brüggemann R., Scherb H., Cok I., Mazmancj B., Mazmancj M., Turgut C., Schramm K., (2014). Py-hasse software features applied on the evaluation of chemicals in human breast milk samples in Turkey. Multi-indicator systems and modeling in partial order. Chapter 17, p. 343-358
- Yokota K, Fukuda M, Katafuchi R, Okamoto T., (2017). Nephrotic syndrome and acute kidney injury induced by malathion toxicity. *BMJ Case Rep* 2017. <https://doi.org/10.1136/bcr-2017-220733>

## Pymetrozine

Pymetrozine is an insecticide, registered in **2 products** to control aphids, white flies and thrips in cabbage, kale and beans.

General aspects	
Registered products containing Pymetrozine	Chess 50 WG Water Fulfil 25SC
Manufacturing companies	Hailir Pesticides & Chemicals Group Co Ltd, China Syngenta AG, Basle, Switzerland.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Cabbages, French beans, Kales, Beans
Pest	Aphids, Whiteflies, Thrips
Alternatives*	Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Pyriproxifen, Sulphur
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021  
 \*\* Pesticide Properties Database: University of Hertfordshire, 2021  
 Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Acute toxic effects always occur from within a few minutes to several hours after poisoning by the pesticide (Yang and Deng, 2007; DeBleecker, 1995; Pereira *et al.*, 2015; Atabila *et al.*, 2018b).

Various chronic diseases and disorders sometimes occur after people have been exposed to pesticides (Wesseling *et al.*, 1997, Uram, 1989, Phung *et al.*, 2012b).

Pymetrozine affects three major areas in the body: the liver, the hematopoietic system and the lymphatic system. In addition, both the subchronic and chronic dog studies suggest that this chemical affects muscle tissue, perhaps secondarily. The most significant effects in these areas are tumors in the livers of mice and rats, necrosis of the liver of mice and dogs, hyperplasia in the bile ducts of dogs, anemia in dogs, atrophy in the thymus of young rats and dogs, and myopathy in the muscle of dogs (US EPA, 2000).

### Carcinogenicity

Pymetrozine is a possible human carcinogen (US EPA, 2010) based on male mouse liver benign hepatoma and/or carcinoma. Hepatocellular hypertrophy is related to induction of drug metabolizing enzymes (US EPA, 2010).

### Reproductive toxicity

Systemic/developmental toxicity was observed at parentally toxic dose levels (US EPA, 2000).

## Food safety issues

Occurrence of pymetrozine in cauliflower from China has been reported (Jia *et al.*, 2018), as well as pymetrozine in beef meat (Oliveira *et al.*, 2018), coffee (Dias *et al.*, 2013), strawberries (Fernandes *et al.*, 2014), tomato, cucumber and watermelon (Camino-Sanchez *et al.*, 2010).

## Environmental toxicity and environmental behavior of concern

Generally low aquatic, bee, bird and earthworm toxicity (EPA factsheet, 2000).

## Pesticide's alternatives

See table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:




























- Carcinogenicity
- Reproductive toxicity

## References

- Atabila, A., Sadler, R., Phung, D. T., Hogarh, J. N., Carswell, S., Turner, S., Patel, R., Connell, D. & Chu, C. (2018b). Biomonitoring of chlorpyrifos exposure and health risk 560 assessment among applicators on rice farms in Ghana. *Environmental Science and Pollution Research*, 25, 20854-20867.
- Camino-Sanchez, F. J., Zafra-Gomez, A., Oliver-Rodriguez, B., Ballesteros, O., Navalon, A., Crovetto, G., & Vilchez, J. L. 2010. UNE-EN ISO/IEC 17025:2005-accredited method for the determination of pesticide residues in fruit and vegetable samples by LC-MS/MS. *Food Additives & Contaminants*, 27(11), 1532-1544.
- Debleecker, J. L. 1995. The intermediate syndrome in organophosphate poisoning: an overview of experimental and clinical observations. *Journal of Toxicology: Clinical Toxicology*, 33, 683- 570 686.
- Dias, C. M., Oliveira, F. A., Madureira, F. D., Silva, G., Souza, W. R., & Cardeal, Z. L. (2013) Multi-residue method for the analysis of pesticides in Arabica coffee using liquid chromatography/tandem mass spectrometry. *Food Additives and Contaminants Part A-chemistry Analysis Control Exposure & Risk Assessment*, 30(7), 1308-1315.
- Fernandes, V. C., Lehotay, S. J., Geis-Asteggianti, L., Kwon, H., Mol, H. G., Van, d. K. H., Mateus, N., Domingues, V.F., & Delerue-Matos, C. (2014). Analysis of pesticide residues in strawberries and soils by GC-MS/MS, LC-MS/MS and two-dimensional GC-time-of-flight MS comparing organic and integrated pest management farming. *Food Additives & Contaminants*, 31(2), 262-270
- Jia, G., Zeng, L., Zhao, S., Ge, S., Long, X., Zhang, Y., Hu, D. (2018). Monitoring residue levels and dietary risk assessment of pymetrozine for Chinese consumption of cauliflower. *Biomedical Chromatography*, <https://doi.org/10.1002/bmc.4455>
- Oliveira, F. A. D. S., Pereira, E. N. C., Gobbi, J. M., Soto-Blanco, B., & Melo, M. M. (2018). Multiresidue method for detection of pesticides in beef meat using liquid chromatography coupled to mass spectrometry detection (LC-MS) after quechers extraction. *Food Additives & Contaminants, Part A*, 35(1), 94-109
- Pereira, L. C., DE Souza, A. O., Bernardes, M. F. F., Pazin, M., Tasso, M. J., Pereira, P. H. & 594 Dorta, D. J. (2015). A perspective on the potential risks of emerging contaminants to human and environmental health. *Environmental Science and Pollution Research*, 22, 13800-13823.
- Phung, D. T., Connell, D., Miller, G., Rutherford, S. & Chu, C. 2012b. Pesticide regulations and farm worker safety: the need to improve pesticide regulations in Viet Nam. *Bulletin of the World Health Organization*, 90, 468-473.
- Uram, C. 1989. International regulation of the sale and use of pesticides. *Nw. J. Int'l L. & Bus.*, 10, 628
- Wesseling, C., Mcconnell, R., Partanen, T. & Hogstedt, C. (1997). Agricultural pesticide use in developing countries: health effects and research needs. *International journal of health 634 services*, 27, 273-308.
- Yang, C.-C. & Deng, J.-F. (2007). Intermediate syndrome following organophosphate insecticide poisoning. *Journal of the Chinese Medical Association*, 70, 467-472.

## Oxydemeton-methyl

Also known as, methylmercaptophos oxide, it is registered in **2 products** to control a variety of sucking and chewing insect pests on citrus, wheat, potatoes, maize and barley.

General aspects	
Registered products containing Oxydemeton-methyl	Metasystox Hattrick EC
Manufacturing companies	United Phosphorus India Orbit Agro Chemical Industries Ltd.
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Citrus, Wheat, Potatoes, Maize, Barley
Pest	Aphids, Thrips, Red Spidermites, Whiteflies
Alternatives*	Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Pyriproxifen, Sulphur Oxymatrine, pyrethroids
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

### Reproductive toxicity

Oxydemeton-methyl has been reported to cause vacuolation of the epithelium of the corpus epididymis in male rats and decrease the corpora lutea in the ovaries and implantation sites in female rats (Abdollahi, 2014).

### Hepatotoxicity

Oxydemeton-methyl causes histopathological changes in the liver, fatty infiltration and necrosis in rats IPCS (2002).

### Carcinogenicity and teratogeni

Musculoskeletal and cardiovascular teratogenic effects were seen in a dose-dependent manner (Abdollahi, 2014).

## Food safety issues

Oxydemeton-methyl residues were reported in cucumbers and tomatoes from Iran with levels exceeding stipulated MRLs (Ganjeizadeh *et al.*, 2014). Oxydemeton-methyl residues above MRLs were also reported in greenhouse vegetables from Iran (Hashemi *et al.*, 2013). There is no published data on occurrence of oxydemeton-methyl residues in foodstuffs in Kenyan markets and the underlying risks to Kenyan consumers are therefore unknown.

## Environmental toxicity and environmental behavior of concern

**High bee toxicity:** Oxydemeton-methyl was found to have short-lived toxicity to honey bees and alkali bees exposed to foliar residues (EPA 2002).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced. Proposed withdrawal in Kenya should be based on:

- Reproductive toxicity
- Neurotoxicity
- Bee toxicity

## References

---

- Abdollahi, M., & Mostafalou. S., (2014). *Encyclopedia of Toxicology (Third Edition)*. Academic Press.
- Ganjeizadeh R., Mahdavi, V., Aminaie, M. (2014). Investigation on diazinon and oxydemeton-methyl residues in cucumbers grown in Kerman greenhouses. *Environmental Monitoring and Assessment*, 186(7), 3995–3999. doi:10.1007/s10661-014-3674-0
- Hashemi, H., Sadeghi, R., Fadaei, A., Sadeghi, M. (2013) Monitoring of Residues of Oxydemeton-Methyl in Greenhouse Vegetables in Shahrekord, Iran. *International Journal of Environmental Protection*, 3 (5).
- IPCS (2002) International Programme on Chemical Safety Pesticide residues in food - 2002 - Joint FAO/WHO Meeting on Pesticide Residues OXYDEMETON-METHYL
- NCBI (2021) National Center for Biotechnology Information (2021). PubChem Compound Summary for CID 4618, Oxydemeton-methyl. Retrieved August 29, 2021 from <https://pubchem.ncbi.nlm.nih.gov/compound/Oxydemeton-methyl>
- US EPA (2006) Office of Pesticide Programs, Health Effects Division, Science Information Management Branch: Chemicals Evaluated for Carcinogenic Potential, (April 2006).





# Fungicides

---

## Chlorothalonil

Chlorothalonil is a broad-spectrum fungicide. In Kenya it is sold in **20 products** and is registered for controlling fungal diseases mainly in French beans, tomatoes and coffee but also in snow peas, cucumber and cabbage, as well as in staple crops like barley and wheat. Farmers use it on butternut, coriander, melon, coffee, French beans, kale, cabbage, tomatoes (KOAN, 2020).

### General aspects

#### Registered products containing Chlorothalonil

Amizoc 480 SC  
Bravo TOP 550SC  
Cherokee 487.5 SE  
Clortocaffaro WP  
Clortosip 75 WP  
Compliant 560 SC  
Daconil 720SC (Bravo 720 SC)  
Dakota 50 FW  
Folio Gold 537.5 SC  
Glider 720 SC  
Katerina 720 SC  
Koban  
Noxnil 72 SC  
Odeon 82.5  
Providence 400 WP  
Rankonil 500 SC  
Rova 500SC  
Rova 75 WP  
Twiga Eponil 600 SC  
Twigathalonil 720SC

#### Manufacturing companies

Adama Makhteshim Ltd, Israel.  
Arysta LifeScience SAS, France.  
Calliope S. A. S, France.  
Jiangsu Xinhe Agrochemical Co., Ltd  
Jiangyin Sulifine Chemicals, China.  
Jiansu Suli Chemicals Co Ltd, China.  
Ningbo Sunjoy Agrosience Co, China  
Ningbo Yihwei Chemicals Co. Ltd.  
Rotam Chemistry Co. Ltd, Hong Kong  
Sipcam UK, Ltd/ Oxon Italia SpA, Pero Italy  
Syngenta Crop Protection AG, Basle, Switzerland.  
Taizhou Bailly Chemical Co Ltd; China  
Vischim s.r.l., Italy / Sipcam UK, Ltd.  
Yifan Biotechnology Group Company Limited

#### HHP

Yes

#### Withdrawn in Europe

Yes

#### Crops treated

French beans, Cabbages

#### Pest

Stem rust, Yellow rust, Coffee berry disease, Powdery mildew, Downey mildew, Bean rust, Aschochytes, Botrytis

#### Alternatives\*

Bupirimate, Sulphur, Captan, Thiophanate-Methyl, Trifloxystrobin, Azoxystrobin  
Prothioconazole, Benalaxl-M, Dimethomorph

**Human Health\*\*****Carcinogenicity****Mutagenicity****Endocrine Disrupter****Reproductive Toxicity****Neurotoxicity****Environmental Health\*\*****Bee Toxicity****Fish Toxicity****Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern**

Chlorothalonil is very toxic if inhaled and less toxic if administered by the oral or dermal route. It is not a skin irritant but irritant to the respiratory tract. It may cause serious eye damage and allergic skin reactions. Chlorothalonil is likely to be a carcinogen but no potential for endocrine disrupting activity, neurotoxicity and reproductive toxicity (European Commission, 2012; EFSA PPR Panel, 2012; EFSA, 2013; ECHA, 2015; Lewis *et al.*, 2016).

**Reproduction**

Chlorothalonil causes inhibition of ovary development in mice (Hao *et al.*, 2019) and in a low dose it impairs spermatogenesis in mice (Zhang *et al.*, 2019).

**Carcinogenicity**

Chlorothalonil induces genotoxicity at field relevant concentrations (Wilkinson and Killeen, 1996; Santovito *et al.*, 2018).

**Food safety issues**

Chlorothalonil residue levels in spinach, kales and African nightshade sold in Nairobi markets have been reported at concentrations above the permissible MRLs (Mungai, 2020). Chlorothalonil has also been reported in vegetables sold in Southern Botswana (Thamani *et al.*, 2021) and in gherkins cultivated in Turkey (Golge *et al.*, 2020).

## Environmental toxicity and environmental behavior of concern

Chlorothalonil has a low aqueous solubility, is volatile and moderately mobile. It is moderately persistent in soil but can be persistent in water systems under certain conditions, so it is expected to be present in water for a long time (Lewis *et al.*, 2016; EFSA, 2018). It was banned for use in Europe in March 2019 because of contamination of ground and surface water by its metabolites, and accompanying risk to aquatic species.

It shows **medium toxicity** towards bees and **high toxicity** towards aquatic species.

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Genotoxicity which results in carcinogenicity (now category 1B)
- Contamination of groundwater by the metabolites
- Risk to aquatic species like amphibians and fish

## References

- ECHA (European Chemicals Agency), (2015). Guidance on the Application of the CLP Criteria; *Guidance to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures*. Version 4.1, June 2015. Reference: ECHA-15-G-05-EN; ISBN: 978-92-9247-413-3; Available online: [http://echa.europa.eu/documents/10162/13562/clp\\_en.pdf](http://echa.europa.eu/documents/10162/13562/clp_en.pdf).
- EFSA PPR Panel (EFSA Panel on Plant Protection Products and their Residues), (2013). Guidance on tiered risk assessment for plant protection products for aquatic organisms in edge-of-field surface waters. *EFSA Journal* 2013; 11(7):3290, 186 pp. <https://doi.org/10.2903/j.efsa.2013.3290>.
- EFSA Scientific Committee, (2013). Scientific Opinion on the hazard assessment of endocrine disruptors: scientific criteria for identification of endocrine disruptors and appropriateness of existing test methods for assessing effects mediated by these substances on human health and the environment. *EFSA Journal* 2013; 11(3):3132, 84 pp. <https://doi.org/10.2903/j.efsa.2013.3132>.
- European Commission, (2012). *Guidance document on the assessment of the equivalence of technical materials of substances regulated under Regulation (EC) No 1107/2009*. SANCO/10597/2003-rev. 10.1.
- European Food Safety Authority (EFSA), Arena, M., Auteri, D., Barmaz, S., Bellisai, G., Brancato, A., & Villar-Bouza, L. (2018). Peer review of the pesticide risk assessment of the active substance chlorothalonil. *EFSA Journal*, 16(1), e05126.
- Golge, O., Cinpolat, S., Kabak, B. (2020). Quantification of pesticide residues in gherkins by liquid and gas chromatography coupled to tandem mass spectrometry. *Journal of Food Composition and Analysis*, 96, 103755. <https://doi.org/10.1016/j.jfca.2020.103755>.
- Hao Y, Zhang H, Zhang P, Yu P, Ma D, Li L, Feng Y, Min L, Shen W, Zhao Y. (2019). Chlorothalonil inhibits mouse ovarian development through endocrine disruption. *Toxicology Letters*, 303: 38-47 <https://doi.org/10.1016/j.toxlet.2018.12.011>.
- KOAN-Kenyan Organic Agricultural Network, (2020). *Pesticide use in Kirinyaga and Murang'a Counties*. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf).
- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016). An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242.
- Mungai J. (2020). *Concentration, reduction efficacy and degradation of chlorothalonil and lambda cyhalothrin pesticides in Vegetables sold in Nairobi Market*. Masters Thesis.
- Santovito, A., Gendusa, C., Ferraro, F., Musso, I., Costanzo, M., Ruberto, S., & Cervella, P. (2018). Genomic damage induced by the widely used fungicide chlorothalonil in peripheral human lymphocytes. *Ecotoxicology and environmental safety*, 161, 578-583.
- Thamani F., Malaki K., Boingotlo O., Tawangwa S., Juda B., Boitshepo M. (2021). Pesticide residues in fruits and vegetables from the southern part of Botswana. *Food additives & contaminants: Part B*. <https://doi.org/10.1080/19393210.2021.1950845hAO>.
- Wilkinson CF, Killeen JC. (1996). A Mechanistic Interpretation of the Oncogenicity of Chlorothalonil in Rodents and an Assessment of Human Relevance. *Regulatory Toxicology and Pharmacology*, 24(1): 69-84. <https://doi.org/10.1006/rtp.1996.0065>.
- Zhang P, Zhao Y, Zhang H., Liu J, Feng Y, Yin S, Cheng S, Sun X, Min L, Li L, Shen W. (2019). Low dose chlorothalonil impairs mouse spermatogenesis through the intertwining of Estrogen Receptor Pathways with histone and DNA methylation. *Chemosphere* 230: 384-395.

## Carbendazim

Carbendazim is a systemic fungicide and is registered in **17 products** for controlling fungal diseases mainly in French beans and tomatoes but also in snow peas, squash, broccoli, onions and capsicum, in staple crops like rice, barley, wheat and in fruits like mangoes, citrus, pawpaw. No registration was found for use on kale or spinach despite residues of carbendazim being found on kales, as reported in the Kenya Plant Health Inspectorate Service (KEPHIS) 2018 annual report (KEPHIS, 2018). Farmers are using it on zucchini, melon, rice, maize, cabbage, kale and tomatoes (KOAN, 2020).

### General aspects

<b>Registered products containing Carbendazim</b>	Goddard 35 SE Seed Pro 30 WS Saaf WP Sherrif 75 WP Megaprode Lock 52.5 WP Rimeta Gold 300 SC Discovery 400 SC Bendazim 500 SC Botran 500 SC Chariot 500 SC Rodazim SC Ransom 600WP Pearl 80 DF Exempo-Curve 250 SC Soprano SC 250 Seed Plus 30WS Companion 75 WP
	Adama Makhteshim Ltd, Israel. Anhui Guangxin Agrochemical Co. Ltd., China/ Ningbo Sunjoy Agrosience Co. Ltd, China Indofil Industries Limited, India Jiangsu Kuaida Agrochemical Ltd, China Ningbo Yihwei Chemical Co. Ltd., China Rotam Agrochemicals, Hong Kong. Shaanxi Hengrun Chemical Industry Co. Ltd, China Shanghai Forever Chemicals Co. Ltd., China Sulphur Mills Ltd., India. Topsen Goldchance Fluence, China/ Sineria Industries Ltd, Cyprus UPL Ltd, India Yantai Keda Chemical Co. Ltd China
<b>Manufacturing companies</b>	
<b>HHP</b>	Yes
<b>Withdrawn in Europe</b>	Yes
<b>Crops treated</b>	French beans, Snow beans, Mangoes, Citrus, Pawpaw, Tomatoes, Rice, Capsicum
<b>Pest</b>	Powdery mildew, Botrytis, Heterosporium, Rhizoctonia, Anthracnose sclerotinia, Grey mold, Fruit rot, Root rot, Angular leaf spot, Rice Blast, Early and late blight, Yellow and stem rust, Phytophthora blight
<b>Alternatives*</b>	Bupirimate, Sulphur, Captan, Thiophanate-Methyl, Trifloxystrobin, Azoxystrobin, Prothioconazole, Benalaxl-M, Dimethomorph



**Human Health\*\*****Carcinogenicity****Mutagenicity****Endocrine Disrupter****Reproductive Toxicity****Neurotoxicity****Environmental Health\*\*****Bee Toxicity****Fish Toxicity****Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern**

Carbendazim is not acutely toxic via the oral, dermal and inhalation routes. It is not a skin or eye irritant but is a skin sensitizer.

However, it shows a wide range of chronic effects. Carbendazim causes embryo toxicity, apoptosis, teratogenicity, infertility, hepatocellular dysfunction, endocrine-disrupting effects, disruption of haematological functions, mitotic spindle abnormalities, mutagenic and aneugenic effects, hepatocellular dysfunction, hepatocellular dysfunction, endocrine-disrupting effects, disruption of haematological functions, mitotic spindle abnormal (Rama *et al.*, 2014; Salihi *et al.*, 2015; Prashantkumar *et al.*, 2012; Daundkar and Rampal, 2014; Adedara *et al.*, 2013)..

**Neurotoxicity**

Neurotoxic signs, consisting of leg weakness, ataxia and/or “goose-stepping” gait, were observed in hens (Goldenthal, 1978; Li *et al.*, 2020).

**Carcinogenicity**

Carbendazim along with carbomyl are classified as possible human carcinogens (Goodson *et al.*, 2015). It causes numerical chromosome aberrations (aneuploidy and/or polyploidy) increasing in the incidence of combined hepatocellular adenomas and carcinomas (Wood, 1982). Under the conditions of 2-year studies, there was evidence of carcinogenic activity of carbendazim in rats based on increased incidences of hormone-dependent tumors without clear dose dependence and reduction of their latent period (Lisovska *et al.*, 2020). It induces hepatic cell proliferation leading to hepatocellular adenomas in mice (APVMA, 2009).



## Reproductive toxicity/Endocrine Disruption

In terms of reproduction, carbendazim causes birth defects and impairs human fertility. Carbendazim is known to cause adverse effects on male reproductive systems, including decreased testicular and epididymal weights and reduced epididymal sperm counts and fertility in the rats (Gray *et al.*, 1990). Yu *et al.* (2009) showed effects on spermatogenesis and fertility in rats. Effect on placenta cells is shown by Zhou *et al.* (2015). Carbendazim influences the hypothalamus–pituitary–gonad axis and is a testicular toxicant (Rama *et al.*, 2014). Exposure of mice to carbendazim caused severe seminiferous tubular atrophy (> 85% of tubules were atrophic) with 16 of the 24 treated males failed to induce a pregnancy, as compared with no failure in the control (Carter *et al.*, 1987).

In addition, the safety of carbendazim needs to be evaluated further, especially the bioaccumulation toxicity and potential genotoxic effects (Li *et al.*, 2020). Carbendazim has a long half-life (up to 6 months) and therefore occupational re-entry exposure can occur for a significant length of time following application.

## Food safety issues

Carbendazim levels above the MRLs set by the EU was reported in French beans from Meru, Kenya (Marete *et al.*, 2020). Tomato samples (52% of all samples) from Meru, Machakos and Kirinyaga counties showed carbendazim levels partly above the MRL (KOAN, 2020; unpublished Route to Food Initiative, 2020). Other studies showed levels above the MRLs set by EU and Codex in tomatoes from Kirinyaga County (Nakhungu *et al.*, 2021, Momanyi *et al.*, 2021). Carbendazim levels in tomatoes from Nairobi markets were reported to be below the EU MRLs (Nguetti, 2019). Carbendazim has a long half-life (up to 6 months) and therefore occupational re-entry exposure can occur for a significant length of time following application. Risk assessments done in Australia demonstrated that re-entry exposure in grapes, stone fruits, custard apples, apples, pears, turf and roses was unacceptable, and these use patterns should not be supported (APVMA, 2009).

## Environmental toxicity and environmental behavior of concern

Carbendazim has a low aqueous solubility, is volatile and moderately mobile. It is moderately persistent in soil and can be **very persistent in water systems** under certain conditions. Although it has not been in use in Europe for several years, carbendazim had been found in a recent study in almost all surface water samples around Europe (Casado *et al.*, 2019). There is no sufficient information to address the route of degradation of carbendazim in soil under aerobic conditions (DE, 2010; EFSA, 2010; Lewis *et al.*, 2016).

Carbendazim degradation results in the formation of 2-amino-benzimidazole, **a highly toxic component**, which binds to the spindle microtubules causing the nuclear division blockade (Yenjerla *et al.*, 2009).

**High aquatic toxicity:** It is highly toxic particularly to the sediment living organisms such as channel catfish (Douglas & Handley, 1987). Immunotoxicity and endocrine disruption in zebrafish (Jiang *et al.*, 2014). See also Palanikumar *et al.*, 2014; Jiang *et al.*, 2015; Andrade *et al.*, 2016.

**Medium to high earthworm toxicity:** Carbendazim significantly reduces earthworm weight and earthworms show avoidance response at field relevant soil concentrations (Rico *et al.*, 2016; Huan *et al.*, 2016). This is critically important as earthworms are crucial for good soil health.

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Persistent in water, soil and plants and the degradation results in the formation of 2-amino-benzimidazole, a highly toxic component
- Occupational risk for farm workers
- Misuse by farmers
- Consumer risk and food safety concerns
- Endocrine disrupting activity and reproductive toxicity
- High toxicity towards bees, aquatic organisms and earthworms




























## References

- Adedara IA, Vaithinathan S, Jubendradass R, Mathur PP, Farombi EO (2013) Kolaviron prevents carbendazim-induced steroidogenic dysfunction and apoptosis in testes of rats. *Environ Toxicol Pharmacol* 35:444–453. doi:10.1016/j.etap.2013.01.010.
- Andrade TS, Henriques JF, Almeida AR, Machado AL, Koba O, Giang PT, Soares AM, Domingues I (2016) Carbendazim exposure induces developmental, biochemical and behavioural disturbance in zebrafish embryos. *Aquat Toxicol* 170:390–399. doi:10.1016/j.aquatox.2015.11.
- Daundkar PS, Rampal S (2014) Evaluation of ameliorative potential of selenium on carbendazim induced oxidative stress in male goats. *Environ Toxicol Pharmacol* 38:711–719. doi:10.1016/j.etap.2014.09.007.
- APVMA (2009) *Australian Pesticides and Veterinary Medicines Authority Australia Chemical Review Program Human Health Risk Assessment of Carbendazim* Prepared by Office of Chemical Safety and Environmental Health Office of Health Protection of the Department of Health and Ageing Canberra June 2008 Revised December 2009.
- Carter SD, Hess RA, & Laskey JW (1987). The fungicide methyl 2-benzimidazolecarbamate causes infertility in male Sprague-Dawley rats. *Biol Reprod*, 37(3): 709-718. Chiba M & Veres DF (1981) Fate of benomyl and its degradation compound methyl 2-benzimidazole carbamate on apple foliage. *J Agric Food Chem*, 29: 588-590.
- Casado, J., Brigden, K., Santillo, D., Johnston, P. (2019). Screening of pesticides and veterinary drugs in small streams in the European Union by liquid chromatography high resolution mass spectrometry. *Science of The Total Environment*, 670: 1204 DOI: 10.1016/j.scitotenv.2019.03.207.
- DE, (2010). *Final Addendum to Assessment Report on carbendazim*, compiled by EFSA.
- Douglas MT & Handley JW (1987) *The algistatic activity of carbendazim technical*. Huntingdon, United Kingdom, Huntingdon Research Centre Ltd (Unpublished report No. DPT 171(g)/871604, prepared for E.I. Du Pont de Nemours and Co., Inc.). Du Pont (1972) Residue studies - fish: benomyl, MBC, and 2-AB. Wilmington, Delaware, E.I. Du Pont de Nemours and Co., Inc. (Unpublished report).
- European Food Safety Authority. (2010). Conclusion on the peer review of the pesticide risk assessment of the active substance carbendazim. *EFSA Journal*, 8(5), 1598.
- Goldenthal EI (1978) *Neurotoxicity in hens*. Mattawan, Michigan, International Research and Development Corporation (Unpublished report No. HLO 27-79, prepared for E.I. Du Pont de Nemours and Co., Inc.).
- Goodson WH, Lowe L, Carpenter DO, Gilbertson M, Ali AM, Lopez de Cerain Salsamendi AL *et al* (2015) Assessing the carcinogenic potential of low-dose exposures to chemical mixtures in the environment: the challenge ahead. *Carcinogenesis* 36:254–296. doi:10.1093/carcin/bgv039.
- Gray L.E. *et al.*, (1990). Carbendazim induced alterations of reproductive development and function in the rat and hamster, *Fundamental and Applied Toxicology*, 15, 281-297.
- Huan Z, Luo J, Xu Z, Xie D (2016) Acute toxicity and genotoxicity of carbendazim, main impurities and metabolite to earthworms (*Eisenia foetida*). *Bull Environ Contam Toxicol* 96:62–69. doi:10.1007/s00128-015-1653-y.
- Jiang J, Wu S, Wang Y, An X, Cai L, Zhao X, Wu C (2015) Carbendazim has the potential to induce oxidative stress, apoptosis, immunotoxicity and endocrine disruption during zebrafish larvae development. *Toxicol In Vitro* 29:1473–1481. doi:10.1016/j.tiv.2015.06.003.
- Jiang, J., Wu, S., Wu, C., An, X., Cai, L., Zhao, X., (2014). Embryonic exposure to carbendazim induces the transcription of genes related to apoptosis, immunotoxicity and endocrine disruption in zebrafish (*Danio rerio*). *Fish & Shellfish Immunology*, 41 (2): 493-500, <https://doi.org/10.1016/j.fsi.2014.09.037>.
- Kenya Plant Health Inspectorate Service (KEPHIS) (2018). *Annual Report and Financial Statement*, Nairobi, Kenya.
- KOAN-Kenyan Organic Agricultural Network, (2020). Pesticide use in Kirinyaga and Murang'a Counties. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf).

- Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016). An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242.
- Li J, Zhou X, Zhang C, Zhao Y, Zhu, Y, Zhang, J, Bai J and Xiao X (2020) The Effects of Carbendazim on Acute Toxicity, Development, and Reproduction in *Caenorhabditis elegans*. *Journal of food quality, Volume 2020* |Article ID 8853537 | <https://doi.org/10.1155/2020/8853537>.
- Lisovska V. S., Nedopytanska N. M., Reshavska O. V., Bagliy Y. A. (2020) Carbendasim Carcinogenicity: An Experimental Two-Year Study In Wistar Rats. *Bulletin of Problems Biology and Medicine / Issue 1 (155)*, 2020/.
- Marete, G. M., Shikuku, V. O., Lalah, J. O., Mputhia, J., & Wekesa, V. W. (2020). Occurrence of pesticides residues in French beans, tomatoes, and kale in Kenya, and their human health risk indicators. *Environmental Monitoring and Assessment*, 192(11), 1-13.
- Momanyi VN, Keraka MN, Abong'o AD & Warutere PN (2021) Pesticide Residues on Tomatoes Grown and Consumed in Mwea Irrigation Scheme, Kirinyaga County, Kenya *Asian Journal of Agricultural and Horticultural Research*, Page 1-11 DOI: 10.9734/AJAHR/2021/v8i230110.
- Nakhungu M., Keraka N., Abong'o A., Warutere N. (2021). Pesticide Residues on Tomatoes Grown and Consumed in Mwea Irrigation Scheme, Kirinyaga County, Kenya. *Asian Journal of Agricultural and Horticultural Research*. 8(2): 1-11.
- Nguetti J. (2019). *Pesticides residues and Microbial contamination of tomatoes produced and consumed in Kenya*. PhD Thesis.
- Palanikumar L, Kumaraguru AK, Ramakritinan CM, Anand M (2014) Toxicity, biochemical and clastogenic response of chlorpyrifos Environ Chem Lett 123 and carbendazim in milkfish *Chanos chanos*. *Int J Environ Sci Technol* 11:765–774. doi:10.1007/s13762-013-0264-6.
- Prashantkumar W, Sethi RS, Pathak D, Rampal S, Saini SP (2012) Testicular damage after chronic exposure to carbendazim in male goats. *Toxicol Environ Chem* 94:1433–1442. doi:10.1080/ 02772248.2012.693493.
- Rama EM, Bortolan S, Vieira ML, Gerardin DC, Moreira EG (2014) Reproductive and possible hormonal effects of carbendazim. *Regul Toxicol Pharmacol* 69:476–486.
- Rico A, Sabater C, Castillo MA' (2016) Lethal and sub-lethal effects of five pesticides used in rice farming on the earthworm *Eisenia fetida*. *Ecotoxicol Environ Saf* 127:222–229. doi:10.1016/j. ecoenv.2016.02.004.
- Salihu M, Ajayi BO, Adedara IA, Farombi EO (2015) 6-Gingerol-rich fraction from *Zingiber officinale* prevents hematotoxicity and oxidative damage in kidney and liver of rats exposed to carbendazim. *Journal of dietary supplements*, 16:1–16.
- Wood CK (1982) *Long-term feeding study with 2-benzimidazole- carbamate, methyl ester (< 99% MBC, INE-965) in mice. Parts I and II*. Newark, Delaware, E.I. Du Pont de Nemours and Co., Inc., Haskell Laboratory (Unpublished report No. HLR 70-82).
- Yenjerla M, Cox C, Wilson L, Jordan MA. (2009) Carbendazim inhibits cancer cell proliferation by suppressing microtubule dynamics. *J Pharmacol Exp Ther*. Feb; 328(2):390-8. doi: 10.1124/jpet.108.143537. Epub 2008 Nov 10. PMID: 19001156; PMCID: PMC2682274.
- Yu, G., Guo, Q., Xie, L., Liu, Y., & Wang, X. (2009). Effects of subchronic exposure to carbendazim on spermatogenesis and fertility in male rats. *Toxicology and Industrial Health*, 25(1), 41–47. <https://doi.org/10.1177/0748233709103033>.
- Zhou, J., Xiong, K., Yang, Y., Ye, X., Liu, J., & Li, F. (2015). Deleterious effects of benomyl and carbendazim on human placental trophoblast cells. *Reproductive Toxicology*, 51, 64-71.

## Thiophanate-methyl

Thiophanate-methyl is a fungicide that is registered in **6 products** to control fungal diseases on a wide range of crops. Farmers in Kenya are using it mainly on rice, maize and tomatoes (KOAN, 2020).

General aspects	
Registered products containing Thiophanate-methyl	Redeem 70 WP Rex duo 497SC Swing extra 497 Tabib 500SC Topguard 50SC Topsin M Liquid
Manufacturing companies	BASF Jiangsu Lanfeng Biochemical Co Ltd, China Jiangsu Lanfen Biochemical Co. Ltd, China Nippon Soda, Japan; Nisso Namhae Agro Co., Ltd, Korea/ Mitsui & Co. Ltd., Japan. Nisso Fine Chemicals Co. Ltd; Japan, , Zhejiang Tide Cropscience Co Ltd, China
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Tomatoes, French beans, Pawpaw, Avocado, Rice, Beans, Banana, Wheat
Pest	Botrytis, Powdery mildew, Rice blast, Angular leaf spot, Leaf rust, Early and late blight, Yellow and stem rust, Leaf mold
Alternatives*	Bupirimate, Sulphur, Captan, Trifloxystrobin, Azoxystrobin Prothioconazole, Benalaxyl-M, Dimethomorph
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Thiophanate-methyl presents a low acute toxicity profile when administered via the oral or dermal routes. If inhaled, it is harmful. It is not a skin or eye irritant but may cause an allergic reaction. It is a possible carcinogen and an endocrine disruptor (European Commission, 2012; EFSA PPR Panel, 2012; ECHA, 2015).

### Reproductive toxicity

Traina *et al.* (1998) observed reduction of maternal weight gain and of daily food consumption after exposure to 650 mg-1 kg-1day of thiophanate-methyl.

### Hepatotoxicity

Some studies indicate that thiophanate-methyl may lead to hepatic morphological alterations, glycogen depletion and hepatocellular apoptosis (Buono *et al.*, 2007). In addition, thiophanate-methyl may change hepatic metabolism of substances administrated concomitantly, which may interfere on the toxicity caused by the commercial formulation.

### Nephrotoxicity

Wilkinson & Killen (1996) reported that chronic exposure of rodents to thiophanate-methyl can cause nephrotoxicity and renal tubular hyperplasia.

## Food safety issues

Thiophanate-methyl has been detected in strawberries grown in Egypt (Malhat *et al.*, 2021), in cucumber (Al-Obaidie and Sumir, 2018), in tea (Chen *et al.*, 2013) and in rapeseed (Chen *et al.*, 2015).

## Environmental toxicity and environmental behavior of concern

Thiophanate-methyl has a low aqueous solubility, low volatility and tends not to be persistent in soil or water systems. It has low potential for groundwater exposure (EFSA, 2017; Lewis *et al.*, 2016). It has a low mammalian toxicity. However, it is an irritant, a skin sensitizer and may also be mutagenic. It is moderately toxic to most aquatic organisms and earthworms but less so to birds and honeybees.

European Commission (2002a, b), SETAC (2001), EFSA (2009), EFSA PPR Panel (2013) and EFSA (2013) show eco-toxicological effects as:

- Low risk to birds and mammals
- Medium acute and chronic risk to fish
- Medium risk to honey bees
- Low risk to non-target arthropods
- Low risk to soil microorganisms
- Low risk to non-target terrestrial plants
- Low risk to biological methods of sewage treatment

## Pesticide's alternatives

Azoxystrobin could potentially constitute a good alternative to thiophanate-methyl (Wang and Zhang, 2018). In addition, see Table above.

## Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced  
 Proposed withdrawal in Kenya should be based on:

- Reproductive toxicity
- Aquatic toxicity



## References

- Al-Obaidie, A. B., Ali, A. J., Sumir, S. H., Al-Samaraie, O. I., & Ali, M. H. (2018). Degradation study of thiophanate-methyl residues in cucumber (*Cucumis sativus*). *Pakistan Journal of Biotechnology*, 13:1–6.
- Buono, S., Cristiano, L., D'angelo, B., Cimini, A., & Putti, R. (2007). PPAR alpha mediates the effects of the pesticide methyl thiophanate on liver of the lizard *Podarcis sicula*. *Comparative Biochemistry and Physiology Part C: Toxicology & Pharmacology*, 145(3), 306-314. <https://doi.org/10.1016/j.cbpc.2006.12.016>.
- Chen H, Liu X, Wang C, Wang Q, Jiang Y, Yin P, Zhu L (2013) Simultaneous determination of thiophanate-methyl and its metabolite carbendazim in tea using isotope dilution ultra-performance liquid chromatography–tandem mass spectrometry. *J Chromatogr Sci* 52:1157–1164.
- Chen, H., Zhang, W., Yang, Z., Tang, M., Zhang, J., Zhu, H., & Zhang, K. (2015). Determination of thiophanate-methyl and carbendazim in rapeseed by solid–phase extraction and ultra–high performance chromatography with photodiode array detection. *Instrumentation Science & Technology*, 43(5), 511-523.
- ECHA (European Chemicals Agency), (2015). *Guidance on the Application of the CLP Criteria; Guidance to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures*. Version 4.1. Reference: ECHA-15-G-05-EN; ISBN: 978-92-9247-413-3; [http://echa.europa.eu/documents/10162/13562/clp\\_en.pdf](http://echa.europa.eu/documents/10162/13562/clp_en.pdf).
- EFSA (European Food Safety Authority), (2009). Guidance on Risk Assessment for Birds and Mammals on request from EFSA. *EFSA Journal* 2009; 7(12):1438, 358 pp. <https://doi.org/10.2903/j.efsa.2009.1438>.
- EFSA PPR Panel (EFSA Panel on Plant Protection Products and their Residues), (2012). Guidance on dermal absorption. *EFSA Journal* 2012; 10(4):2665, 30 pp. <https://doi.org/10.2903/j.efsa.2012.2665>.
- EFSA (European Food Safety Authority), (2013). EFSA Guidance Document on the risk assessment of plant protection products on bees (*Apis mellifera*, *Bombus* spp. and solitary bees). *EFSA Journal* 2013; 11(7):3295, 268 pp., <https://doi.org/10.2903/j.efsa.2013.3295>.
- EFSA Panel on Plant Protection Products and their Residues (PPR). (2013). Guidance on tiered risk assessment for plant protection products for aquatic organisms in edge-of-field surface waters. *EFSA Journal*, 11(7), 3290, 186 pp. <https://doi.org/10.2903/j.efsa.2013.3290>.
- EFSA (European Food Safety Authority), (2017). *Peer review report to the conclusion regarding the peer review of the pesticide risk assessment of the active substance thiophanate-methyl*. Available online: [www.efsa.europa.eu](http://www.efsa.europa.eu).
- European Commission, (2002a). *Guidance Document on Terrestrial Ecotoxicology Under Council Directive 91/414/EEC*. SANCO/10329/2002-rev. 2 final, 17 October 2002a.
- European Commission, (2002b). *Guidance Document on Aquatic Ecotoxicology Under Council Directive 91/414/EEC*. SANCO/3268/2001-rev. 4 final, 17 October 2002b.
- European Commission, (2012). *Guidance document on the assessment of the equivalence of technical materials of substances regulated under Regulation (EC) No 1107/2009*. SANCO/10597/2003-rev. 10.1, 13 July 2012.
- KOAN-Kenyan Organic Agricultural Network, (2020). *Pesticide use in Kirinyaga and Murang'a Counties*. [https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper\\_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf](https://www.koan.co.ke/wp-content/uploads/2020/10/WhitePaper_-Pesticide-Use-in-Muranga-and-Kirinyaga-Counties-2020.pdf).
- Lewis, K. A., Tzilivakis, J., Warner, D. J., & Green, A. (2016). An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242.
- Malhat, F., Abdallah, O., Ahmed, F., Salam, S. A., Anagnostopoulos, C., & Ahmed, M. T. (2021). Dissipation behavior of thiophanate-methyl in strawberry under open field condition in Egypt and consumer risk assessment. *Environmental Science and Pollution Research*, 28(1), 1029-1039. <https://doi.org/10.1007/s11356-020-10186-4>.

SETAC (Society of Environmental Toxicology and Chemistry), (2001). *Guidance document on regulatory testing and risk assessment procedures for plant protection products with non-target arthropods*. ESCORT 2.

Traina, M. E., Fazzi, P., Macrì, C., Ricciardi, C., Stazi, A. V., Urbani, E., & Mantovani, A. (1998). In vivo studies on possible adverse effects on reproduction of the fungicide methyl thiophanate. *Journal of Applied Toxicology*, 18(4), 241-248 doi: 10.1002/(sici)1099-1263(199807/08)18:4<241::aid-jat500>3.0.co;2-q. PMID: 9719423.

Wang, H. C., & Zhang, C. Q. (2018). Multi-resistance to thiophanate-methyl, diethofencarb, and procymidone among *Alternaria alternata* populations from tobacco plants, and the management of tobacco brown spot with azoxystrobin. *Phytoparasitica*, 46(5), 677-687.

Wilkinson CF & Killeen JC. (1996). A mechanistic interpretation of the oncogenicity of chlorothalonil in rodents and an assessment of human relevance. *Regul Toxicol Pharmacol* 24: 69-84.



## Mancozeb

Mancozeb is a commonly used fungicide. It is registered in **71 products** to control fungal diseases on tomatoes, potatoes, French beans and cabbage. It is the pesticide most used by farmers in Kirinyaga and Murang'a counties, and it is used on all crops in the area (KOAN, 2020).

### General aspects

#### Registered products containing Mancozeb

























Acrobat 69% MZ  
 Agrilax 72 WP  
 Agrithane WP  
 Agromax MZ 720 WP  
 Amimax 720WP  
 Belthane 80 WP  
 Biothane 80WP  
 Bonus 72WP  
 Cadillac 80WP  
 Companion 75 WP  
 Corum 72% W  
 Curzate M 44 WP  
 Dithane Dg, Rainshield  
 Dithane M-45  
 Dithchem 80 WP  
 Emalaxyl 68 WP  
 Emthane-45 WP  
 Envy 72 WP  
 Eureka 80 WP  
 Fantic M 4-65 WG  
 Farmcozeb 75WG  
 Farmmil 72 WP  
 Fortress gold 72 WP  
 Forum 690 WP  
 Galben M8-65  
 Globe 76 WP  
 Hanthane 80  
 Indofil M45 WP  
 Ivory 80 WP  
 Kentthane 80 WP  
 Lavidia 73 WDG  
 Mancobex 80WP  
 Mancoflo 455SC  
 Mancolax WP  
 Matco 72WP  
 Metacozeb 72  
 Micene 76WP  
 Millionaire 69% WDG  
 Novazez 80  
 Novithane 80 WP  
 Oshothane Plus WDG  
 Penncozeb 80  
 Pyramid 700 WP  
 Saaf WP  
 Samurai 72 WP  
 Sancobez 80 WP  
 Senator 80 WP  
 Sherrif 75 WP  
 Skipper 720 WP

**Registered products  
containing Mancozeb**

Milthane Super  
 Mistress 72 WP  
 Mitazeb 80 WP  
 Mosthane 80  
 Murthane 80  
 Novazeb 80  
 Novithane 80 WP  
 Oshothane Plus WDG  
 Penncozeb 80  
 Pyramid 700 WP  
 Saaf WP  
 Samurai 72 WP  
 Sancobez 80 WP  
 Senator 80 WP  
 Sherrif 75 WP  
 Skipper 720 WP  
 Stargem 80WP  
 Tajiri 72WP  
 Tata master  
 Topstar 72 WP  
 Tower 72 WP  
 Tridex 80 WP  
 Trinity Gold 452 Wettable powder  
 Twigalaxyl 72% WP  
 Ugonall 580 WP  
 Upron 72WP  
 Uthane WP  
 Vidalia 69WP  
 Vondozeb 75 DG  
 Zeblight 80 WP  
 Zetanil 76 WP

**Manufacturing companies**

Agria S.A, Bulgaria  
 BASF SE, Germany  
 Cerexagri S.A., Plaisir, France.  
 Dow Agrosciences France, Columbia and Brazil.  
 Dow AgroSciences Ltd.-UK  
 Dow Agrosciences, USA / Sipcam Oxon SpA, Italy.  
 Dow Agrosciences/Sanachem(pty) S.A.  
 DuPont  
 FMC Corporation, USA.  
 Hailir pesticide and chemical group Co Ltd, China  
 Hebei Shuangji Chemical Co., Ltd., China  
 Indofil Chemical Industries, India.  
 Jiangbo Agrochemical Technology Company Ltd, china  
 Jiangsu Baoling Chemical Co. Ltd., China Exporter: Shanghai Qiaoji International Ltd.  
 Jiangsu United Agrochemical Co Ltd, China  
 Limin Chemical Co Ltd, China  
 Nantong Baoye Chemical Co. Ltd., China  
 Ningbo Sunjoy Agroscience Co, China  
 Ningbo Yihwei Chemicals Co. Ltd., China  
 Rallis Ltd., India.  
 Rotam Agrochemical Co. Ltd., China  
 Sabero Organics Ltd. / Mosum Enterprises.  
 Servatis S.A Brazil/ Jiangsu Huifeng Agrochemicals Co. Ltd., China/BASF  
 AGRO B.V. /BASF SE, Germany.

<b>Manufacturing companies</b>	Shandong Cynda Chemical Co. Ltd Shandong Weifang Shuangxing Pesticide Co Ltd. Shanghai Hui Song (H&S) Agro-Solution Co. Ltd, China. Shanghai Shenglian Chemical Co. Ltd., China Sulphur Mills India UPL Ltd, India / Swal Corporation Ltd., India UPL Ltd., India / Dera Chemical Industries. Xi an Mpc Stock Co Ltd, China XIAN MPC Stock Co. Ltd, China Yifan Biotechnology Group Co. Ltd., China Zhejiang Jiahua Chemical Co., Ltd, China
<b>HHP</b>	Yes
<b>Withdrawn in Europe</b>	Yes
<b>Crops treated</b>	Tomatoes, Potatoes, French beans, Cabbages, Onions
<b>Pest</b>	Early and late blight, Downy mildew, Rust, Botrytis, Angular leaf spot
<b>Alternatives*</b>	Bupirimate, Sulphur, Captan, Thiophanate-Methyl, Trifloxystrobin, Azoxystrobin, Prothioconazole, Benalaxl-M, Dimethomorph
<b>Human Health**</b>	
<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  
<b>Environmental Health**</b>	
<b>Bee Toxicity</b>	  
<b>Fish Toxicity</b>	  
<b>Earthworm Toxicity</b>	  
<b>Bird Toxicity</b>	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Mancozeb demonstrates low acute toxicity by the oral, dermal and inhalation routes. It is neither a skin nor an eye irritant, but it is a moderate skin sensitizer. It is a possible carcinogen. It also has potential for reproductive toxicity and endocrine disrupting activity (European Commission, 2003, 2012; ECHA and EFSA, 2018; EFSA PPR Panel,

2012; EFSA, 2014; Lewis *et al.*, 2016; ECHA, 2017; ECHA, 2019). Mancozeb has the potential to induce a variety of health issues, including hepatic, renal, and genotoxic effects (Pirozzi *et al.*, 2016; Ahmed *et al.*, 2017; Atamaniuk *et al.*, 2013; Intranuovo *et al.*, 2018; Yahia *et al.*, 2015).

### Neurotoxicity

Acute exposure to high doses of mancozeb produces equipotent toxic effects in both DA and GABA neurons that may be associated with perturbations in mitochondrial respiration (Lisa *et al.*, 2006).

### Hepatotoxicity

Mancozeb-treated lettuce induces change in plasmatic concentration of total protein. This impairment may result in liver dysfunction through diminution of protein synthesis (Chrisman *et al.*, 2009).

### Carcinogenicity

Mancozeb is a **multipotent carcinogenic agent**: Animals treated with mancozeb in food from age 8 weeks through age 104 weeks and followed until spontaneous death showed a significant increase in total tumors and in tumors of specific type that were often sex specific. Mancozeb was shown to be carcinogenic on the basis of the number of total malignant tumors and the tumors at various sites that included malignant mammary tumors, Zymbal gland and ear duct carcinomas, hepatocarcinomas, malignant tumors of the pancreas, malignant tumors of the thyroid gland, osteosarcomas of the bones of the head, and hemolymphoreticular neoplasias (Fiorella, *et al.*, 2006). Srivastava *et al.*, (2012) proved genotoxicity.

### Reproductive toxicity

Results from in vitro studies provide evidence that mancozeb may indirectly disrupt or impair reproduction at the cellular level and should be regarded as a reproductive toxicant. Animal studies confirm reproductive and developmental toxicity in mammals and suggest that males chronically exposed to mancozeb experience significant changes in physiological, biochemical, and pathological processes that may lead to infertility (Runkle *et al.*, 2017).

### Endocrine toxicity

Mancozeb exposure is associated with increased incidence of thyroid disease in female spouses of pesticide applicators (Goldner *et al.*, 2010). Hypothyroxinemia early in pregnancy is associated with adverse effects on the developing nervous system and can lead to impaired cognitive function and motor development in children (Adjrah *et al.*, 2011). Thyroid toxicity was manifested as alterations in thyroid hormones, increased thyroid weight, and microscopic thyroid lesions (mainly thyroid follicular cell hyperplasia), and thyroid tumors.

## Food safety issues

Mancozeb was detected in brinjal and grapes from Pune-India though below the EU-MRL (Mujarwa *et al.*, 2014) and in lettuce (López-Fernández *et al.*, 2013) and in tomatoes from Central Uganda (Kaye *et al.*, 2015). There are no data for Kenya.

## Environmental toxicity and environmental behavior of concern

It has low aqueous solubility, is quite volatile, and is not expected to leach to groundwater (Lewis *et al.*, 2016; EFSA, 2020). It is not persistent in soil systems but may be persistent in water under certain conditions. Mancozeb has low mammalian toxicity but has been associated with adverse reproduction/development effects. It is highly toxic to fish and aquatic invertebrates, and moderately toxic to birds and earthworms. The toxicity of mancozeb to honeybees is low.

**High aquatic Toxicity:** Mancozeb has been shown to cause detrimental effects to fish and invertebrates (Sharma *et al.*, 2016). There is a high mortality rate of fish exposed to mancozeb irrespective of the exposure time (Nimai *et al.*, 2016). The metabolite of mancozeb (ethylenethiourea) contaminates the groundwater (Srivastava and Singh, 2013). Ethylenethiourea is responsible for thyroid dysfunction and carcinogenic effects in various organisms (Sharma *et al.*, 2016).

**Medium bird toxicity:** as thyroid disrupting potential hence influences seasonally breeding wildlife birds (Surya, 2015).

## Pesticide's alternatives

See Table above

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal should be based on:

- Carcinogenicity
- Reproductive toxicity
- Endocrine Disrupter
- Aquatic toxicity
- Widely used by farmers

## References

- Ahmed, A., Ahmed, A., & Gamila, K. (2017). Hemato-biochemical responses under stress of Mancozeb fungicide (75 % WP) in male albino rat. *International Journal of Advanced Research in Biological Sciences*, 4(10), 116-127.
- Adjrah, Y., Karou, S.D., Agbonon, A., Eklu-gadegbeku, K., de Souza, C. & Gbeassor, M. (2013) Toxicological Assessment of Effect of Mancozeb-Treated Lettuce (*Lactuca sativa*) On Wistar Rat Liver. *Ethiopian Journal of Environmental Studies and Management*, 6(1), 67-73
- Atamaniuk, T.M., Kubrak, O.I., Husak, V.V., Storey, K.B., & Lushchak, V.I. (2013). The mancozeb-containing carbamate fungicide tattoo induces mild Oxidative Stress in goldfish brain, liver, and kidney. *Environmental Toxicology*, 29(11), 1227-1235.
- Chrisman, J.R., Koifman, S., Sarcinelli, P.N., Moreira, J.C., Koifman, R.J., & Meyer, A. (2009). Pesticides sales and adult cancer mortality in Brazil. *International Journal of Hygiene and Environmental Health*, 212, 310–321.
- ECHA (European Chemicals Agency). (2017). Guidance on the Application of the CLP Criteria; Guidance to Regulation (EC) No 1272/2008 on classification, labelling and packaging (CLP) of substances and mixtures. Version 5.0, July 2017. Reference: ECHA-17-G-21-EN; ISBN: 978-92-9020-050-5; Available online: <https://echa.europa.eu/guidance-documents/guidance-on-clp>
- ECHA (European Chemicals Agency). (2019). Committee for Risk Assessment (RAC) Opinion proposing harmonised classification and labelling at EU level of mancozeb. CLH-O-0000001412-86-263/F. Available online: [www.echa.europa.eu](http://www.echa.europa.eu).
- ECHA & EFSA (European Chemicals Agency and European Food Safety Authority) with the technical support of the Joint Research Centre (JRC), Andersson, N., Arena, M., Auteri, D., Barmaz, S., Grignard, E., Kienzler, A., Lepper, P., Lostia, A.M., Munn, S., Parra Morte, J.M., Pellizzato, F., Tarazona, J., Terron, A., & Van der Linden, S. (2018). Guidance for the identification of endocrine disruptors in the context of Regulations (EU) No 528/2012 and (EC) No 1107/2009. *EFSA Journal*, 16(6), 5311. <https://doi.org/10.2903/j.efsa.2018.5311>.
- EFSA (European Food Safety Authority). (2014). Guidance on the assessment of exposure of operators, workers, residents and bystanders in risk assessment for plant protection products. *EFSA Journal* 2014;12(10):3874, 55 pp. <https://doi.org/10.2903/j.efsa.2014.3874> Available online: [www.efsa.europa.eu/efsajournal](http://www.efsa.europa.eu/efsajournal)
- EFSA. (2020). Peer review of the pesticide risk assessment of the active substance mancozeb. *EFSA Journal*, 18(12), e05755.
- EFSA PPR Panel (EFSA Panel on Plant Protection Products and their Residues). (2012). Guidance on dermal absorption. *EFSA Journal* 2012, 10(4), 2665, 30 pp. <https://doi.org/10.2903/j.efsa.2012.2665>
- European Commission. (2003). Guidance Document on Assessment of the Relevance of Metabolites in Ground-water of Substances Regulated under Council Directive 91/414/EEC. SANCO/221/2000-rev. 10 final, 25 February 2003.
- European Commission. (2012). Guidance document on the assessment of the equivalence of technical materials of substances regulated under Regulation (EC) No 1107/2009. SANCO/10597/2003-rev. 10.1, 13 July 2012.
- Goldner, W.S., Sandler, D.P., Yu, F., Hoppin, J.A., Kamel, F., & Levan, T.D. (2010). Pesticide use and thyroid disease among women in the Agricultural Health Study. *American Journal of Epidemiology*, 171, 455–464.
- Fiorella, B., Morando, S., Marina, G., Luca, L., Daniela, C., & Cesare, M. (2002). Results of Long-Term Experimental Studies on the Carcinogenicity of Ethylene-bis-Dithiocarbamate (Mancozeb) in Rats. *Annals of the New York Academy of Sciences*, 982, 123-136
- Intranuovo, G., Schiavulli, N., Cavone, D., Birtolo, F., Cocco, P., Vimercati, L., Macinagrossa, L., Giordano, A., Perrone, T., Ingravallo, G., Mazza, P., Strusi, M., Spinosa, C., Specchia, G., & Ferri, G.M. (2018). Assessment of DNA damages in lymphocytes of agricultural workers exposed to pesticides by comet assay in a cross-sectional study. *Biomarkers*, 23, 462-473.

- Runkle, J., Flocks, J., Economos, J., & Dunlop, A.L. (2017). A systematic review of Mancozeb as a reproductive and developmental hazard. *Environmental International*, 99, 29-42
- Kenyan Organic Agricultural Network (KOAN). 2020. *Pesticide use in Kirinyaga and Murang'a Counties*. <https://www.koan.co.ke/>
- Lisa, M.D., Gail, D.Z., Laura, P.B., & Keith, R.C. (2006). Acute neurotoxic effects of mancozeb and maneb in mesencephalic neuronal cultures are associated with mitochondrial dysfunction. *NeuroToxicology*, 27(5), 816-825
- López-Fernández, O., Rial-Otero, R., & Simal-Gándara, J. (2013). Factors governing the removal of mancozeb residues from lettuces with washing solutions. *Food Control*, 34(2), 530–538.
- Kaye, E., Nyombi, A., Mutambuze, I., & Muwesa, R. (2015). Mancozeb Residue on Tomatoes in Central Uganda. *Journal of Health and Pollution*, 5(8), 1–6.
- Mujawar, S., Utture, S., Fonseca, E., Matarrita, J., & Banerjee, K. (2014). Validation of a GC–MS method for the estimation of dithiocarbamate fungicide residues and safety evaluation of mancozeb in fruits and vegetables. *Food Chemistry*, 150, 175–181.
- Nimai, C.S., Santosh, K.G., Nishan, C., Surjyo, J.B., & Suman, B. (2016). Acute toxic effects of Mancozeb to fish *Oreochromis mossambicus* (W. K. H. Peters, 1852) and their behavior. *International Journal of Advanced Research in Biological Sciences*, 3(6), 40-44
- Pirozzi, A., Stellavato, A., La Gatta, A., Lamberti, M., & Schiraldi, C. (2016). Mancozeb, a fungicide routinely used in agriculture, worsens nonalcoholic fatty liver disease in the human HepG2 cell model. *Toxicology Letters*, 249: 1-4.
- Sharma, M.R., Mushtaq, R., Allayie, S.A., & Vardhan, H. (2016). Assessment of lethal toxicity of mancozeb and its consequences on the behavior of fresh water fish, *puntius ticto*. *Journal of International Academic research for Multidisciplinary*, 4(2), 132-138.
- Srivastava, A.K., Ali, W., Singh, R., Bhui, K., Tyagi, S., Al-Khedhairi, A., Srivastava, P.K., Musarrat, J., & Shukla, Y. (2012). Mancozeb-induced genotoxicity and apoptosis in cultured human lymphocytes. *Life Sciences*, 90(21-22), 815-824.
- Surya, P.P., & Banalata, M. (2015). The neonicotinoid pesticide imidacloprid and the dithiocarbamate fungicide mancozeb disrupt the pituitary–thyroid axis of a wildlife bird. *Chemosphere*, 122, 227-234.
- Yahia, E., Aiche, M.A., Chouabbia, A., Boulakoud, M.S., & Mokthar, B. (2015). Biochemical and hematological changes following long term exposure to mancozeb. *Advances in BioResearch*, 6(2), 83-86



## Tebuconazole

Tebuconazole is a fungicide registered in **30 products** for the control of fungal diseases on various crops. Farmers in Kirinyaga and Murang'a counties do not use it frequently, only on French beans (KOAN, 2020).




























### General aspects

#### Registered products containing Tebuconazole

SKYWAY XPRO 275 EC  
 TANALITH ECO 3443 SL  
 EVITO T 477 EC  
 PROSARO 250 EC  
 APRIL COMBI 38.3 EW  
 MICROPLUS DISPERSS 74.5  
 RAXIL SUPER 375  
 AZIMUT 320 SC  
 TEBICON 25 EW  
 KING 250 EW Oil  
 ORIZOLE 250 EC  
 AMNESTY 250 EW  
 ARIZONA 250 EW  
 DUCASSE 250 EW  
 EAZOLE 250 EC  
 FEZAN 250 EW  
 FOLICUR 250 EW  
 HORNET 250 EC  
 MERRYZOLE 250 EW  
 ORIUS 25 EW  
 RUSTKILLER 250 EW  
 SEVENCONAZOLE 250  
 STAGE 250EW  
 TEBUCURE 250 EW  
 TOLEDO 250 EC  
 WARRIOR 25 EW  
 SILVACUR 375 EC  
 APRIL COMBI 38.3 EW  
 X-SPORE 43SC  
 NATIVO SC 300

#### Manufacturing companies

Bayer CropScience, USA  
 Arch Timber Protection Ltd., UK  
 Jiangsu Sevencontinent Green Chemical Co Ltd, China  
 Bayer AG, Germany  
 Shanghai Heben Eastern Medicaments, China  
 Sulphur & Tebuconazole United phosphorous Ltd  
 Meghmani Industries Ltd. Ahmedabad, Gujarat, India  
 Sharda Worldwide Exports Pvt. Ltd; Registrant: Sineria (Industries) Ltd Cyprus  
 Jiangsu Sevencontinent Green Chemical Co., Ltd., China  
 Shandong Sino-Agri United Biotechnology Co. Ltd, China  
 Ningbo Yihwei Co. Ltd., China  
 Ningbo Sunjoy Agrosience Co. Ltd., China.  
 Astec Lifesciences  
 Adama Makhteshim. Ltd, Israel  
 Shandong Sino-Agri United Biotechnology Co. Ltd, China  
 Sharda Worldwide Exports Pvt Ltd, India.  
 Rotam Agrochemicals Company Ltd.Hong Kong  
 Irvita Plant Protection N.V., Netherlands / Makhteshim Chemical Works Ltd.  
 Jiangsu Fengdeng Pesticide Co Ltd, China  
 Jiangsu Qiaoji Biochem Co. Ltd, China  
 Syngenta Crop Protection AG, Switzerland.

<b>HHP</b>	Yes
<b>Withdrawn in Europe</b>	No
<b>Crops treated</b>	Mangoes, Maize, Beans, French beans, Barley, Wheat, Cabbages
<b>Pest</b>	Yellow and stem rust, Septoria, Powdery mildew, Anthracnose, Net blotch, Ring spot, Fusarium species, Spot blotch
<b>Alternatives*</b>	Bupirimate, Sulphur, Captan, Thiophanate-Methyl, Trifloxystrobin, Azoxystrobin, Prothioconazole, Benalaxl-M, Dimethomorph
<b>Human Health**</b>	
<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  
<b>Environmental Health**</b>	
<b>Bee Toxicity</b>	  
<b>Fish Toxicity</b>	  
<b>Earthworm Toxicity</b>	  
<b>Bird Toxicity</b>	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

Tebuconazole is of low toxicity through the dermal and inhalation route and of moderate acute toxicity through the oral route. It is neither a skin nor an eye irritant. It is also not a skin sensitizer (European Commission, 2003, 2004b, 2005).

### Neurotoxicity

Generally low neurotoxicity. Perinatal exposure to tebuconazole produced adverse effects, altered learning in a spatial cognitive task, and hippocampal and neocortical neuropathology (Moser, et al., 2001).

### Hepatotoxicity

Results demonstrate a statistically significant induction of the AHR target genes CYP1A1 and CYP1A2 in HepG2 and HepaRG human liver cells in vitro at concentrations corresponding to tebuconazole tissue levels reached under subtoxic conditions in vivo (Knebel *et al.*, 2019).

### Reproductive toxicity

Rats had increased incidence of malformations and increased number of resorptions at maternal toxic dose (EFSA, 2014). Treatment of rats with tebuconazole decreased glutathione content and increased glutathione S-transferase, superoxide dismutase, catalase, and glutathione peroxidase activities in liver; increased superoxide dismutase activities in kidney and testis; but decreased glutathione S-transferase activity in testis. Treatments with tebuconazole decreased serum testosterone concentration and cauda epididymal sperm count (Liang, 2013). It is suspected of damaging fertility or the unborn child (EFSA, 2014).

### Food safety issues

Tebuconazole concentrations 750 times higher than the MRL, was reported in oranges (Mac *et al.*, 2018). Residues below MRL were reported in watermelon and jujube from China (Dong and Hu, 2014; You *et al.*, 2017). Tebuconazole has also been reported in apples (Patyal *et al.*, 2013). No residues have been detected in Kenya food items.

### Environmental toxicity and environmental behavior of concern

In soil under aerobic conditions, tebuconazole exhibits moderate to medium persistence forming the soil metabolite 1, 2, 4-triazole which exhibits moderate to high persistence. In soil, tebuconazole shows high to low mobility while, 1,2,4-triazole exhibits very high to high mobility. Tebuconazole has low potential for groundwater exposure (EFSA, 2014).

**Medium aquatic toxicity:** Toxic to aquatic organisms and fish (Sancho *et al.*, 2016; Dimitrov *et al.*, 2014). Insufficient data are available to assess the aquatic risk of the unknown transformation products of tebuconazole (Storck *et al.*, 2016).

Tebuconazole application decreases soil microbial biomass and activity (Muñoz-Leoz *et al.*, 2011).

### Pesticide's alternatives

See Table above

### Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced.

Proposed withdrawal in Kenya should be based on:

- Carcinogenicity
- Reproductive toxicity
- Insufficient toxicological data for mammals, birds and metabolite

## References

- Dimitrov, M.R., Kosol, S., Smidt, H., Buijse, L., Van den Brink, P.J., Van Wijngaarden, R.P., Brock, T.C., & Maltby, L. (2014). Assessing effects of the fungicide tebuconazole to heterotrophic microbes in aquatic microcosms. *Science of the Total Environment*, 490, 1002-1011.
- Muñoz-Leoz, B., Ruiz-Romera, E., Antigüedad, I., & Garbisu, C. (2011). Tebuconazole application decreases soil microbial biomass and activity. *Soil Biology and Biochemistry*, 43, 2176–2183.
- Dong, B., & Hu, J. (2014). Dissipation and residue determination of fluopyram and tebuconazole residues in watermelon and soil by GC-MS. *International Journal of Environmental Analytical Chemistry*, 94(5), 493–505.
- EFSA. (2014). Conclusion on the peer review of the pesticide risk assessment of the active substance tebuconazole. *EFSA Journal*, 12(1), 3485.
- European Commission. (2003). *Guidance Document on Assessment of the Relevance of Metabolites in Groundwater of Substances Regulated under Council Directive 91/414/EEC*. SANCO/221/2000-rev. 10 - final, 25 February 2003.
- European Commission. (2004). *Guidance Document on Dermal Absorption*. SANCO/222/2000 rev. 7, 19 March 2004.
- European Commission. (2005). *Guidance Document on the Assessment of the Equivalence of Technical Materials of Substances Regulated under Council Directive 91/414/EEC*.
- Knebel, C., Heise, T., Zanger, U.M., Lampen, A., Marx-Stoelting, P., & Braeuning, A. (2019). The azole fungicide tebuconazole affects human CYP1A1 and CYP1A2 expression by an aryl hydrocarbon receptor-dependent pathway. *Food Chemistry and Toxicology*, 123, 481-491.
- Liang, Y., Mengli, C., Yihua, L., Wenjun, G., Guonian, Z. (2013). Thyroid endocrine disruption in zebrafish larvae following exposure to hexaconazole and tebuconazole. *Aquatic Toxicology*, 138-139, 35-42.
- Mac, L., Peluso, M., Etchegoyen, M., Alonso, L., Ma, C., Percudani, M., & Damián, J.G. (2018). Pesticide residues in fruits and vegetables of the Argentine domestic market: occurrence and quality. *Food Control*, 93, 129-138.
- Moser, V.C., Barone, Jr., Smialowicz, R.J., Harris, M.W., Davis, D., Mauney, M., & Chapin, R.E. (2001). The Effects of Perinatal Tebuconazole Exposure on Adult Neurological, Immunological, and Reproductive Function in Rats. *Toxicology Sciences*, 62(2), 339-352.
- Patyal, S.K., Sharma, I.D., Chandel, R.S., & Dubey, J.K. (2013). Dissipation kinetics of trifloxystrobin and tebuconazole on apple (*Malus domestica*) and soil—A multi location study from north western Himalayan region. *Chemosphere*, 92(8), 949-954
- Sancho, E. Villarroel, M.J., & Ferrando, M.D. (2016). Assessment of chronic effects of tebuconazole on survival, reproduction and growth of *Daphnia magna* after different exposure times. *Ecotoxicology and Environmental Safety*, 124, 10-17.
- Storck, V., Lucini, L., Mamy, L., Ferrari, F., Papadopoulou, E., Nikolaki, S., Karas, P., Servien, R., Karpouzas, D.G., Trevisan, M., Benoit, P., & Martin-Laurent, F. (2015). Identification and characterization of tebuconazole transformation products in soil by combining suspect screening and molecular typology. *Environmental Pollution*, 208, 537-545
- You, X., Li, Y., Wang, X., Xu, J., Zheng, X., & Sui, C. (2017). Residue analysis and risk assessment of tebuconazole in jujube. *Biomedical Chromatography*, 31(7), e3917. <https://doi.org/10.1002/bmc.3917>
































# Herbicides

---

**2,4-D Amine**

2,4-D Amine is a selective phenoxy herbicide and plant growth regulator and is registered in **5 products** in Kenya.

**General aspects**

<b>Registered products containing 2,4 -D Amine</b>	AGRIMINE 2,4 D 720 SL KEN 2,4D 720 SL PRO 2.4D 720 SL SINE 4 D 720 SL AGROMINE 860 SL
<b>Manufacturing companies</b>	Hangzhou Yilong Chemical Industries, Ltd China Nanjing Agrochemicals Co., Ltd
<b>HHP</b>	Yes
<b>Withdrawn in Europe</b>	No
<b>Crops treated</b>	-
<b>Pest</b>	Weeds
<b>Alternatives*</b>	-
<b>Human Health**</b>	
<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  
<b>Environmental Health**</b>	
<b>Bee Toxicity</b>	  
<b>Fish Toxicity</b>	  
<b>Earthworm Toxicity</b>	  
<b>Bird Toxicity</b>	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

2,4-D toxic effects involve the heart, central and peripheral nervous systems, liver, kidneys, muscles, lungs, and endocrine system (Islam *et al.*, 2017). Classified as a mutagen, carcinogenic, endocrine-disruptor, and acute toxicity (EFSA Journal, 2018). It is harmful if swallowed and toxic if inhaled. No sufficient information is available to reach conclude on the relative toxicity of the individual isomers of (EZ)-1,3-dichloropropene (EFSA Journal, 2018). 2,4-D has been associated with liver effects in a human case report, and in rats and mice, and with reproductive toxicity in males in some studies in rats. Excessive doses may affect digestive systems.

### Carcinogenicity

2,4-Dichlorophenoxyacetic acid (2,4-D) is possibly carcinogenic to humans (Group 2B) (Smith *et al.*, 2016). Rapid and repeated division of blood cells occurs in pesticide applicators who use 2,4-D (Figg *et al.*, 2000). These results were confirmed by laboratory tests in a study led by a researcher at the University of California, Berkeley (Holland *et al.*, 2002). A study led by a researcher at the Medical College of Ohio found that 2,4-D increased the activity of a tumor gene in the liver (Ge *et al.*, 2002).

### Mutagenicity

The National Institute for Occupational Safety and Health labels three forms of 2,4-D (the acid, the sodium salt, and the dimethylamine salt) as mutagens (NIOSH, 2005). Research from the University of Minnesota found that the frequency of a chromosome rearrangement in pesticide applicators was correlated with the level of 2,4-D in their urine (Garry *et al.*, 2001). Scientists at the Institute for Medical Research and Occupational Health (Croatia) found that a commercial 2,4-D herbicide caused chromosome breaks in human blood cells (Zeljezic, 2004). Two studies from the National Research Centre in Egypt and the Bulgarian Academy of Sciences showed that 2,4-D caused chromosome breaks in mouse bone marrow (Amer, 2001).

### Endocrine disrupter

Synergistic androgenic effects when combined with testosterone (Lewis *et al.*, 2016).

## Food safety issues

In 2015, the European Food Safety Authority (EFSA) reported the results of the control activities related to pesticide residues in food carried out in 2013 in the European Union member states, Norway and Iceland (EFSA, 2018). As part of this monitoring program, 2,4-D was analyzed in 2756 food samples and found to be above the limit of quantification (LOQ) for a single result. The measured concentration of 2,4-D in one lettuce sample was 0.075 mg/kg, and thus higher than the maximum residue level (MRL) of 0.05 mg/kg. Furthermore, 2,4-D and its derivative has been detected in wheat and are levels below the Codex MRL (Liu *et al.*, 2012; Jiang *et al.*, 2010). 2,4-D was undetected in cucumber and tomato samples from Iran (Shahrehabak *et al.*, 2019). There is no published data on the occurrence of 2,4-D and its derivatives in food samples grown in Kenya.

## Environmental toxicity and environmental behavior of concern

Medium toxicity to bees, aquatic life, birds and earthworms.

## Pesticide's alternatives

### Microbial herbicides

Microbial herbicides are now being commercialized and have a wider spectrum of efficacy, and thus more market potential. The MBI 005, uses the *Bacillus thuringiensis* strategy. The microbe itself is killed before release into the environment, limiting dispersal from the application site (Zhou *et al.* 2004; Abu-Dieyeh and Watson 2007ab; Hashman, 2011).

The microbial *Streptomyces acidiscabies* is grown in a production facility where it produces herbicidal secretions. The living organism is then killed and harvested along with the herbicide it has produced. This method of production allows the use of a broad spectrum microbial that poses no non-target problems in the field. Since it is not alive, it cannot grow and spread beyond the release point. According to Tom Hashman of Marrone Bio Innova-



tions, “Our testing and review of activity show both pre-emergent and post-emergent activity across a variety of broadleaf, grass, and sedge weeds. There is excellent crop tolerance in grassy crops such as cereals, rice, and corn; we also see the excellent utility in various turf species” (Hashman, 2011).

## Proposed action in Kenya

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced.

Proposed withdrawal in Kenya should be based on:

- Carcinogenicity
- Mutagenicity
- Bee, aquatic, bird and earthworm toxicity
- Food safety

## References

- Abu-Dieyeh, M.H., & Watson, A.K. (2009). Increasing the efficacy and extending the effective application period of a granular turf bioherbicide by covering with jute fabric. *Weed Technology*, 23(4), 524-530.
- Amer, S.M., & Aly, F.A.E. (2001). Genotoxic effect of 2,4-dichlorophenoxy acetic acid and its metabolite 2,4-dichlorophenol in mouse. *Mutation Research*, 494, 1-12.
- EFSA. (2018). Peer review of the pesticide risk assessment of the active substance (EZ)-1,3-dichloropropene. *EFSA Journal*, 16(11), e5464,29
- EPA. (2015). Animal toxicity studies: Effects and end-points (Toxicity Reference Database - ToxCast ToxRefDB files). Washington (DC): United States Environmental Protection Agency. Available from: [https://www3.epa.gov/research/COMPTOX/animal\\_toxicity\\_data.html](https://www3.epa.gov/research/COMPTOX/animal_toxicity_data.html).
- Figg, L.W., Nina, T., Nathaniel, R., Shelia, H., Tarone, E., Hill, R., Vogt, F., Smith, T., Cathy, D., Holmes, F., Karen, V., & Blair, A. (2000). Increased lymphocyte replicative index following 2,4-dichlorophenoxyacetic acid herbicide exposure. *Cancer Causes Control*, 11(4), 373-380.
- Garry, V.F., Tarone, R.E., Kirsch, I.R., Abdallah, J.M., Lombardi, D.P., Long, L.K., Burroughs, B.L., Barr, D.B., & Kesner, J.S. (2001). Biomarker correlations of urinary 2,4-D levels in foresters: Genomic instability and endocrine disruption. *Environmental Health Perspectives*, 109, 495-500.
- Ge, R., Tao, L., Kramer, P.M., Cunningham, M.L., & Pereira, M.A. (2002). Effect of peroxisome proliferators on the methylation and protein level of the c-myc protooncogene in B6C3F1 mice liver. *Journal of Biochemical and Molecular Toxicology*, 16, 41-47.
- Hashman, T. (2011). Pers. Comm., Tom Hashman, Marrone Bio Innovations, Davis, CA.
- Health Canada. (2010). Report on human biomonitoring of environmental chemicals in Canada. Results of the Canadian Health Measures Survey Cycle 1 (2007–2009). Ottawa (ON): Health Canada. Available from: [http://www.hc-sc.gc.ca/ewh-semt/alt\\_formats/hecs-sesc/pdf/pubs/contaminants/chms-ecms/reportrapport-eng.pdf](http://www.hc-sc.gc.ca/ewh-semt/alt_formats/hecs-sesc/pdf/pubs/contaminants/chms-ecms/reportrapport-eng.pdf)
- Holland, N.T., Duramad, P., Rothman, N., Figgs, L.W., Blair, A., Hubbard, A., & Smith, M.T. (2002). Micronucleus frequency and proliferation in human lymphocytes after exposure to herbicide 2,4-dichlorophenoxyacetic acid in vitro and in vivo. *Mutation Research*, 521, 165-178.
- National Institute for Occupational Safety and Health. (2003-2005). Registry of Toxic Effects of Chemical Substances. Query for Chemical Abstract Services numbers 2008-39-1, 94-75-7, and 2702-72-9 through NISC International, Inc's BiblioLine Basic Chemical Information System. [www.nisc.com](http://www.nisc.com).
- Islam, F., Wang, J., Farooq, M.A., Khan, M.S.S., Xu, L., Zhu, J., Zhao, M., Muñoz, S., Li, Q. & Zhou, W. (2017). Potential impact of the herbicide 2,4-dichlorophenoxyacetic acid on human and ecosystems. *Environment International*, 111, 332-351.
- Liu, C., Li, L., Wang, S., You, X., Jiang, S., & Liu, F. (2012). Dissipation and residue of 2,4-D isooctyl ester in wheat and soil. *Environmental Monitoring and Assessment*, 184(7), 4247–4251.
- Lewis, K.A., Tzilivakis, J., Warner, D., & Green, A. (2016) An international database for pesticide risk assessments and management. *Human and Ecological Risk Assessment: An International Journal*, 22(4), 1050-1064.
- NIOSH (The National Institute for Occupational Safety and Health). (2005). NIOSH Pocket Guide to Chemical Hazards. <https://www.cdc.gov/niosh/npg/npgd0173.html>
- Shahrehabak, S., Saber-Tehrani, M., Faraji, M., Shabanian, M., & Aberoomand-Azar, P. (2019). Simultaneous magnetic solid phase extraction of acidic and basic pesticides using triazine-based polymeric network modified magnetic nanoparticles/graphene oxide nanocomposite in water and food samples. *Microchemical Journal*, 146, 630-639.
- Smith, M.T., Guyton, K.Z., Gibbons, C.F., Fritz, J.M., Portier, C.J., Rusyn, I., DeMarini, D.M., Caldwell, J.C., Kavlock, R.J., Lambert, P.F., Hecht, S.S., Bucher, J.R., Stewart, B.W., Baan, R.A., Coglian, V.J., Straif, K.
















(2016). Key Characteristics of Carcinogens as a Basis for Organizing Data on Mechanisms of Carcinogenesis. *Environmental Health Perspectives*, 124(6), 713– 721.

Zeljezic, D., & Garaj-Vrhovac, V. (2004). Chromosomal aberrations, micronuclei and nuclear buds induced in human lymphocytes by 2,4-dichlorophenoxyacetic acid pesticide formulation. *Toxicology*, 200, 39-47.

Zhou, L.C., Bailey, K.L., & Derby, J. (2004). Plant colonization and environmental fate of the biocontrol fungus *Phoma macrostoma*. *Biological Control*, 30(3), 634-644.

## Clodinafop

Clodinafop is an herbicide for annual grass weed control usually used as the propargyl variant. It is registered in **5 products** in Kenya.

General aspects	
Registered products containing Clodinafop	TWIGAMEXYL 080 EC TOPIK 080 CLODIGAN 240 EC CLODEX 100 EC TWIST 100 EC
Manufacturing companies	Syngenta Crop Protection Ag Agan Chemical Manufacturers Ltd, Israel. Invectra Agro Ltd, Hangzhou, China
HHP	-
Withdrawn in Europe	No
Crops treated	Wheat
Pest	Setalia, Setaria, Avena, Elensina, Rye grass, Annual grass weed
Alternatives*	-
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  
Earthworm Toxicity	  
Bird Toxicity	-

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

No data are found on human toxicity.

## Food safety issues

No data

## Environmental toxicity and environmental behavior of concern

It is not expected to be persistent in soil systems but, under ascertain conditions it can be persistent in aquatic systems. Based on its physio-chemical properties it may leach to groundwater. Based on the data available it is moderately toxic to most biodiversity. It may be a mammalian reproduction/developmental toxin. A low acute and long-term dietary risk was concluded for birds (EFSA, 2018).

**Medium aquatic organisms:** A medium acute and long-term risk for fish and aquatic invertebrates (including sediment dwellers) was concluded (EFSA, 2018).

**Medium bee toxicity:** A medium acute (oral and contact) risk for honeybees was concluded (EPPO, 2010).

## Pesticide's alternatives

-

## Proposed action in Kenya






















Active ingredient that may be **retained**, assuring that necessary mitigation measures, extensive training programs and Integrated Pest Management strategies are in place.

## References

- 
- Australia. Pesticides and Veterinary Medicines Authority. (2009). Chemical Review Program Human Health Risk Assessment of Carbendazim. <https://apvma.gov.au/sites/default/files/publication/14531-carbendazim-prf-vol2.pdf>
- European Food Safety Authority. (2005). Conclusion regarding the peer review of the pesticide risk assessment of the active substance clodinafop. *EFSA Journal* 2005, 3(8), 78 <https://doi.org/10.2903/j.efsa.2005.34ar>
- European and Mediterranean Plant Protection Organisation. (2010). *EPPO Standards PP 3/10 (3) Environmental risk assessment for plant protection products*. Chapter 10: honey bees. Bulletin OEPP/EPPO Bulletin, 40, 323–331.

## Oxyfluorfen

Oxyfluorfen is a broad-spectrum, pre-and post-emergent herbicide used to control certain annual weeds in vegetables and fruits. It is registered in **10 products** in Kenya.

General aspects	
Registered products containing Oxyfluorfen	ZOOMER COMBI 390 SC GALAXY 340 EC PREDATOR 340 EC OXYFEN 240 EC OXYGOLD 24 WEEDMAX 240 EC COMMANDER 240 EC GALIGAN 240 EC OXYCLEAN 240 EC GOAL SUPREME 480 SC
Manufacturing companies	Adama Agan LTD Israel Ningbo Sunjoy Agrosience Ltd, China Shandong Huayang Pesticide Chemical Industry Group Co., Ltd., China Yifan Biotechnology Group Co. Ltd, China Huili Import & Export Company Limited, China Shandong Qiaochang Modern Agriculture Co.Ltd, China Zhejiang Yifan Chemical Co. Ltd Shaanxi Sunger Road Bio-Science Co. Ltd, China Shangyu Nutrichem Co Ltd, China
HHP	Yes
Withdrawn in Europe	Yes
Crops treated	Cabbages, Broccoli, Onions, Tomatoes, Pineapples
Pest	Grasses, Broad-leaved weeds, Grass weeds
Alternatives*	-
Human Health**	
Carcinogenicity	  
Mutagenicity	  
Endocrine Disrupter	  
Reproductive Toxicity	  
Neurotoxicity	  
Environmental Health**	
Bee Toxicity	  
Fish Toxicity	  



**Earthworm Toxicity****Bird Toxicity**

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

**Human health effects of concern****Carcinogenicity**

Based on combined hepatocellular adenomas/carcinomas in the mouse carcinogenicity research, oxyfluorfen is categorized as a potential human carcinogen (Level 2b). There was no indication of mutagenic, teratogenic, or reproductive consequences. Oxyfluorfen (> 98 percent purity) has the ability to cause mouse liver tumors via a nongenotoxic, mitogenic MOA with a defined threshold, although it is not expected to be carcinogenic in humans at relevant exposure levels (Stagg, *et al.*, 2012).

**Hepatotoxicity**

Alterations in the spleen, kidney and haematopoietic system were recorded in rats. Oxyfluorfen is devoid of any genotoxic potential (EFSA, 2010).

**Food safety issues**

Oxyfluorfen residues exceeding the set MRL were reported in tomato and cucumber fruits from Khartoum, Sudan (Mohamed *et al.*, 2018). Oxyfluorfen has also been detected in plum from Algeria at levels exceeding MRL (Mebdoua *et al.*, 2017). Oxyfluorfen was detected in high concentrations in tomatoes, onions, and sweet paper from Tanzania (Kapeleka *et al.*, 2020).

**Environmental toxicity and environmental behavior of concern**

Oxyfluorfen is persistent and relatively immobile in soil (Wu *et al.*, 2019). It shows high aquatic toxicity.

**Pesticide's alternatives**

Microbial herbicide

**Proposed action in Kenya**

Active ingredient for **phased withdrawal** as less toxic alternatives are developed and introduced. Proposed withdrawal in Kenya should be based on:

- Carcinogenicity

## References

- Mohamed, A.O., Mater, A.A., Hammad, A.M., Ishag, A.E., El Tayeb, E.M. & Dahab, A.A. (2018). Pesticide residues detected on tomato and cucumber fruits grown in greenhouse farms in Khartoum State, Sudan. *International Journal of Life Sciences Research*, 6(3),472–81.
- European Food Safety Authority. (2010). Conclusion on the peer review of the pesticide risk assessment of the active substance oxyfluorfen. *EFSA Journal* 2010, 8(11):1906. [78 pp.]. doi:10.2903/j.efsa.2010.1906.
- Kapeleka, J.A., Sauli, E., Sadik, O., Ndakidemi, P. & Ratnasekhar, C. (2020). Co-exposure risks of pesticides residues and bacterial contamination in fresh fruits and vegetables under smallholder horticultural production systems in Tanzania. *PLOS ONE*, 15(7). doi:10.1371/journal.pone.0235345.
- ua, S., Lazali, M., Ounane, S., Tellah, S., Nabi, F. & Ounane, G. (2017). Evaluation of pesticide residues in fruits and vegetables from Algeria. *Food Additives & Contaminants: Part B*, 10(2), 91–98. doi:10.1080/19393210.2016.1278047.
- Stagg, N. J., LeBaron, M. J., Eisenbrandt, D. L., Gollapudi, B. B., & Klaunig, J. E. (2012). Assessment of possible carcinogenicity of Oxyfluorfen to humans using mode of action analysis of rodent liver effects. *Toxicological Sciences*, 128(2), 334-345. <https://doi.org/10.1093/toxsci/kfs157>.
- Wu, C., Liu, X., Wu, X., Dong, F., Xu, J., & Zheng, Y. (2019). Sorption, degradation and bioavailability of oxyfluorfen in biochar-amended soils. *Science of the Total Environment*, 658, 87-94. <https://doi.org/10.1016/j.scitotenv.2018.12.059>














## Glufosinate-ammonium

Glufosinate-ammonium is a herbicide for control of a wide range of weeds. It is registered in **2 products** in Kenya.

### General aspects

<b>Registered products containing Glufosinate - ammonium</b>	BASTA 20 SL GLUSAR 18% SL
<b>Manufacturing companies</b>	Bayer AG, Germany. Jiangsu Luye Agrochemicals Co., Ltd., China
<b>HHP</b>	Yes
<b>Withdrawn in Europe</b>	Yes
<b>Crops treated</b>	Banana, Passion, Barley, Wheat, Maize
<b>Pest</b>	Grass, Broad leaf weeds
<b>Alternatives</b>	-

### Human Health\*\*

<b>Carcinogenicity</b>	  
<b>Mutagenicity</b>	  
<b>Endocrine Disrupter</b>	  
<b>Reproductive Toxicity</b>	  
<b>Neurotoxicity</b>	  

### Environmental Health\*\*

<b>Bee Toxicity</b>	  
<b>Fish Toxicity</b>	  
<b>Earthworm Toxicity</b>	  
<b>Bird Toxicity</b>	  

\* Safer inputs database: Kenya Organic Agriculture Network, 2021

\*\* Pesticide Properties Database: University of Hertfordshire, 2021

Note: green circle = low; orange circle = medium; red circle = high

## Human health effects of concern

### Acute toxicity

Glufosinate can cause a range of effects from substantial, but temporary eye injury, skin irritation, respiratory failure, to death through dermal absorption or ingestion. Any contact with the substance can result in some sort of deleterious effect. These effects may vary according to glufosinate formulations and in comparison to technical grade glufosinate. Case reports describe symptoms of ingestion that include convulsions, respiratory distress, disturbed and loss of consciousness, tremor, speech impairment, circulatory failure, and loss of short-term memory (Tamaka *et al.*, 1998; Watanabe *et al.*, 1998; Hirose *et al.*, 1999).

### Reproduction toxicity

The substance is proposed to be classified as reprotoxic Category 2, with laboratory experiments causing premature birth, intra-uterine death and abortions in rats. Studies have reported that glufosinate is toxic to mouse embryos in vitro (in glass containers) and causes growth retardation and neuroepithelial cell death (Watanabe *et al.*, 1996). Paternal exposure to glufosinate in humans has been found to correlate with a possible risk in congenital malformations (Garcia *et al.*, 1996).

### Neurotoxicity

Neurotoxicity can result from glufosinate poisoning, although the mechanism is not clear (Beyond Pesticides, 2016). Exposure to glufosinate in mice at 5 and 10 mg/kg over a period of 10 weeks is shown to result in cerebral alterations, specifically mild memory impairments, modification of hippocampal texture, and a significant increase in hippocampal glutamine synthetase activity (Calas *et al.*, 2008).

## Food safety issues

The European Food Safety Authority expressed serious concerns about the risks for consumers, operators and the environment. Glufosinate-ammonium was reported in green tea, black tea, oolong tea, dark tea, white tea, and yellow tea from China though at concentrations below acceptable risk level (Wang *et al.*, 2021) and in fruits and vegetables (You *et al.*, 2015).

## Environmental toxicity and environmental behavior of concern

Low toxicity

## Pesticide's alternatives

Microbial herbicide

## Proposed action in Kenya

Active ingredient that must be **withdrawn immediately**.

Proposed withdrawal in Kenya should be based on:

- Consumer risk
- Reproductive toxicity
- Neurotoxicity

## References

- Beyond Pesticides. (2016). Glufosinate-ammonium Factsheet. *Pesticides and You*, 36(1), 22. <https://www.beyond-pesticides.org/assets/media/documents/GlufosinateChemWatch.pdf>
- Calas AG, *et al.*, (2008). Chronic exposure to glufosinate-ammonium induces spatial memory impairments, hippocampal MRI modifications and glutamine synthetase activation in mice. *NeuroToxicology*, 29, 740-747. <http://www.sciencedirect.com/science/article/pii/S0161813X08000703>.
- Hirose Y, *et al.*, (1999). A toxicokinetic analysis in a patient with acute glufosinate poisoning. *Hum Exp Toxicol.*, 18, 305-308. <http://www.ncbi.nlm.nih.gov/pubmed/10372751?dopt=Abstract>.
- García AM, *et al.*, (1998) Paternal exposure to pesticides and congenital malformations. *Scandinavian Journal of Work, Environment & Health*. 1998;24:473-480. [http://www.jstor.org/stable/40966810?seq=1#page\\_scan\\_tab\\_contents](http://www.jstor.org/stable/40966810?seq=1#page_scan_tab_contents).
- Tanaka J, *et al.*, (1998). Two cases of glufosinate poisoning with late onset convulsions. *Vet Hum Toxicol.* 40, 219-222. <http://www.ncbi.nlm.nih.gov/pubmed/9682408?dopt=Abstract>.
- TOXNET database. *Glufosinate*. Retrieved March 11, 2016 from <http://toxnet.nlm.nih.gov/>
- Wang Y., Wanjun G., Yeyun L., Yu Xi., Wei S., Ting Y., Manhuan C., Wenjuan W., Ruyan H. (2021). Establishment of a HPLC–MS/MS Detection Method for Glyphosate, Glufosinate-Ammonium, and Aminomethyl Phosphoric Acid in Tea and Its Use for Risk Exposure Assessment. *J. Agric. Food Chem.* 2021, 69, 7969–7978. <https://doi.org/10.1021/acs.jafc.1c01757>
- Watanabe T and Sano T., (1998). Neurological effects of glufosinate poisoning with a brief review. *Hum Exp Toxicol.* <http://www.ncbi.nlm.nih.gov/pubmed/9491336?dopt=Abstract>.
- Watanabe T and Iwase T., (1996). Developmental and dysmorphogenic effects of glufosinate ammonium on mouse embryos in culture. *Teratogenesis, Carcinogenesis, and Mutagenesis*. 16, 287-299. <http://www.ncbi.nlm.nih.gov/pubmed/9178451>.
- You L., Yong-gang S., Yi X., Shi Y., Zhao, S., *et al.* (2015). Determination of Glufosinate Residue in Vegetables and Fruits by Liquid Chromatography-Tandem Mass Spectrometry with Purification of Solid Phase Extraction. [https://en.cnki.com.cn/Article\\_en/CJFDTotal-TEST201509003.htm](https://en.cnki.com.cn/Article_en/CJFDTotal-TEST201509003.htm)

## Appendix 1. Methodology - Toxicity Scores

Each active ingredient was categorized according to its toxicity as follows:

For each active ingredient, we looked up the following different toxicity data in the Pesticide Properties Database (FOOTPRINT, 2006), which provides toxicity information on all active ingredients worldwide (Table 1).

**Table 1. Categories of toxicity according to PPDB**

Wildlife toxicity (Bees, fish) [mg/L]	Chronic human health		
Very toxic	<0.1	Yes	Carcinogenicity
Toxic	0.1 - 1.0	Possible	Mutagenicity
Moderately toxic	1.0 - 10	No	Reproduction Toxicity
Low toxic	10 - 100	No data	Neurotoxicity
Not toxic	>100		Endocrine disruption

**Table 2. Categories for mobility according to PPDB**

<2.8	High mobility
2.8-1.8	Medium
<1.8	Low
No KOC or DT50 value	No data

Accordingly we assigned scores to each given toxicity value following the below criteria (applied and published by Dabrowski *et al.*, 2009).

**Table 3. Scoring system used to rank pesticides for environmental and human health effects**

Toxic effect	Classification	Value
<b>Environment</b>		
Bees, fish, etc	<0.1	4
	0.1 - 1.0	3
	1.0 - 10	2
	10 - 100	1
	>100	0
	No data	2
Mobility (solubility, persistence)	<2.8	4
	2.8 - 1.8	2
	<1.8	1
	No data	1.5
<b>Human Health</b>		
Endocrine Disrupting Acitivity	Yes	8
	Possible	6



<b>Endocrine Disrupting Activity</b>	No data	3
	No	0
<b>Carcinogenicity</b>	Yes	8
	Possible	6
	No data	3
	No	0
<b>Mutagenicity</b>	Yes	6
	Possible	4
	No data	2
	No	0
<b>Reproduction</b>	Yes	4
	Possible	2
	No data	1
	No	0
<b>Neurotoxicity</b>	Yes	4
	Possible	2
	No data	1
	No	0

## Appendix 2. Toxicity score of active ingredients

To determine a total toxicity score for each active ingredient, all scores were summed for the environment (fish, daphnia, bee, algae, mobility) and for human health (carcinogenicity, mutagenicity, reproduction, EDC, neurotoxicity). The toxicity scores can be used as a method for prioritising which pesticides should be withdrawn first. The higher the score, the greater the toxicity potential.

Active ingredient	Environmental score	Human Health Score	Total Score	Proposed Action in Kenya
Permethrin	17	24	41	Withdraw immediately
Bifenthrin	16	24	40	Withdraw immediately
Malathion	14	22	36	Withdraw immediately
Dichlorvos	12	23	35	Withdraw immediately
Carbaryl	14	20	34	Withdraw immediately
Carbendazim	11	22	33	Withdraw immediately
Chlorothalonil	13	20	33	Withdraw immediately
Chlorpyrifos	19	14	33	Withdraw immediately
Mancozeb	13	20	33	Withdraw immediately
Carbofuran	14,5	18	32,5	Ban
Thiacloprid	8	24	32	Phased withdrawal
Gamma-cyhalothrin	15	16	31	Phased withdrawal
Deltamethrin	15	14	29	Phased withdrawal
Omethoate	11	16	27	Withdraw immediately
Flufenoxuron	11	16	27	May be retained
Flubendiamide	16	10	26	May be retained
Oxyfluorfen	10	16	26	Phased withdrawal
Abamectin	15,5	10	25,5	Phased withdrawal
Imidacloprid	12	13	25	Withdraw immediately
Tebuconazole	10	15	25	Withdraw immediately
Acephate	4	19	23	Withdraw immediately
Clodinafop	10	13	23	May be retained
Fenitrothion	12	10	22	Phased withdrawal
Thiophanate-methyl	5	17	22	Phased withdrawal
Pymetrozine	3	17	20	Withdraw immediately
2,4 D-Amine	3	17	20	Withdraw immediately
Dimethoate	8	12	20	Withdraw immediately
Oxydementon Methyl	8	10	18	Phased withdrawal
Glufosinate-Ammonium	2	10	12	Withdraw immediately

**Reference:** Toxicity potential ranking scheme based on the methodology used by James Michael Dabrowski, Justinus Madimetja Shadung, Victor Wepener in their study "Prioritizing agricultural pesticides used in South Africa based on their environmental mobility and potential human health effects" published in *Environment International*, Volume 62, 2014, Pages 31-40. <https://doi.org/10.1016/j.envint.2013.10.001>.



Sio siasa, ni presha.  
[www.routetofood.org](http://www.routetofood.org)

