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
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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). 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). 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, glyphosate, paraquat and triadimefon. 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;

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

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


5 Specific to the active ingredients listed in this dossier and currently under review by the PCPB.
PESTICIDES IN THE KENYAN MARKET

- 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. 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:

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

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6 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).

<table>
<thead>
<tr>
<th align="left">General aspects</th>
</tr>
</thead>
</table>
| **Registered products containing acephate** | 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 |
| **Manufacturing companies** | 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 |
| **Highly Hazardous Pesticide (HHP)** | Yes |
| **Withdrawn in Europe** | Yes |
| **Crops treated** | Maize |
| **Pest** | Armyworm |
| **Alternatives*** | Neem (Azadirachtin): Fortune, Magneto, Nimbecidine, Ozoneem, Neemark, Achook  
Pyrethroids  
Spinosad, Flubendiamide, Diflubenzuron, Chlorantraniliprole |
| **Human Health**** | 
| **Carcinogenicity** | |
| **Mutagenicity** | |
| **Endocrine Disrupter** | |
| **Reproductive Toxicity** | |
| **Neurotoxicity** | |
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 Mutyambai, 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, λ-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


**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

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<td>Acaramik</td>
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<td>Acoster 5 EC</td>
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<td>Adventure 5G</td>
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<tr>
<td>Agrimec 18 EC</td>
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<td>Akrimactin 1.8EC</td>
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<td>Almecin 1.8% EC</td>
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<tr>
<td>Alonze 50 EC</td>
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<tr>
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<td>Apex 40 EC</td>
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<tr>
<td>Armada 1.8 % EC</td>
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<tr>
<td>Avid 1.8 EC</td>
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<td>Avirmec 1.8 EC</td>
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<td>Barbican 10.2 EC</td>
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<td>Bazooka 18EC</td>
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<td>Chordata 10.2 EC</td>
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<tr>
<td>Deacarid 1.8EC</td>
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<td>Dynamic 1.8 EC</td>
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<td>Emperor Top 100 SC</td>
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<td>Foscap 105 GR</td>
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<td>Jundo 88 EC</td>
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<td>Knockbectin</td>
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<td>Konzano 50EC</td>
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<td>Verkotin 1.8% EC</td>
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<td>Zoro Tm 18EC</td>
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### 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.
## Pesticides in the Kenyan Market

**Biodiversity and Biosafety Association Kenya**

### Manufacturing Companies

- China / Cheminova A/S Denmark
- Jiangsu Qiaoji Biochem Co. Ltd., China
- Jinan Shibang Agrochem Co. Ltd, China
- Ningbo Sunjoy Agroscience Co, China
- Rotam Agrochemicals, Hong Kong
- 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

### HHP

<table>
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<th>Withdrawn in Europe</th>
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### Crops Treated

- Tomatoes, Cabbages, French beans, Broccoli, Snow peas, Potatoes, Chilies

### Pest

- Red spider mites, Leaf miners, Thrips, Aphids

### 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
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⁻¹ and 0.01 mg kg⁻¹, respectively (Codex, 2015). The half-life of abamectin and ivermectin varies between 2 and 4 days in milk (Imperiale et al., 2004; Cerkvenik-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; Cerkvenik-Flajs et al., 2007). Therefore, it has been suggested to avoid using milk and its products within 30 days post cattle treatment (Cerkvenik-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


**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

<table>
<thead>
<tr>
<th>Registered products containing Bifenthrin</th>
<th>Genocide 25EC</th>
<th>Bridge 80SC</th>
<th>Brigade 25EC</th>
<th>Defender 2.5% EC</th>
<th>Disect 10 EC</th>
<th>Seizer 80SC</th>
<th>Super grain dust</th>
<th>Talstar 100 EC</th>
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<td>Manufacturing companies</td>
<td>FMC Corporation USA</td>
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<tr>
<td>Crops treated</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Pest</td>
<td>Aphids, Whiteflies, Thrips, Caterpillars, Leaf miners, Spider mites, Bollworms, Diamond back moth</td>
<td></td>
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</tr>
<tr>
<td>Alternatives*</td>
<td>Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin)</td>
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<tr>
<td></td>
<td>Diffenbuzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Fluembendamide, Sulphur, Teflubenzuron, Etofenprox</td>
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</tr>
</tbody>
</table>

### Human Health**

| Carcinogenicity                          | O | O | O |
| Mutagenicity                            | O | O | O |
| Endocrine Disrupter                     | O | O | O |
| Reproductive Toxicity                   | O | O | O |
| Neurotoxicity                           | O | O | O |

### Environmental Health**

| Bee Toxicity                            | O | O | O |
| Fish Toxicity                           | O | O | O |
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 Starner, 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 lg L$^{-1}$ 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


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.


# 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

<table>
<thead>
<tr>
<th>Registered products containing Dichlorvos</th>
<th>Divipan 100F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing companies</td>
<td>Adama Makhteshim Ltd</td>
</tr>
<tr>
<td>HHP</td>
<td>Yes</td>
</tr>
<tr>
<td>Withdrawn in Europe</td>
<td>Yes</td>
</tr>
<tr>
<td>Crops treated</td>
<td>Coffee</td>
</tr>
<tr>
<td>Pest</td>
<td>Mites, Aphids, Thrips</td>
</tr>
</tbody>
</table>

| Alternatives*                           | Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin) Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur |

<table>
<thead>
<tr>
<th>Human Health**</th>
<th><img src="green.png" alt="Green Circle" /></th>
<th><img src="orange.png" alt="Orange Circle" /></th>
<th><img src="red.png" alt="Red Circle" /></th>
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</thead>
<tbody>
<tr>
<td>Carcinogenicity</td>
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<tr>
<td>Mutagenicity</td>
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<tr>
<td>Endocrine Disrupter</td>
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<tr>
<td>Reproductive Toxicity</td>
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<tr>
<td>Neurotoxicity</td>
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<table>
<thead>
<tr>
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<th><img src="orange.png" alt="Orange Circle" /></th>
<th><img src="red.png" alt="Red Circle" /></th>
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</thead>
<tbody>
<tr>
<td>Bee Toxicity</td>
<td><img src="green.png" alt="Green Circle" /></td>
<td><img src="orange.png" alt="Orange Circle" /></td>
<td><img src="red.png" alt="Red Circle" /></td>
</tr>
<tr>
<td>Fish Toxicity</td>
<td><img src="green.png" alt="Green Circle" /></td>
<td><img src="orange.png" alt="Orange Circle" /></td>
<td><img src="red.png" alt="Red Circle" /></td>
</tr>
<tr>
<td>Earthworm Toxicity</td>
<td><img src="green.png" alt="Green Circle" /></td>
<td><img src="orange.png" alt="Orange Circle" /></td>
<td><img src="red.png" alt="Red Circle" /></td>
</tr>
<tr>
<td>Bird Toxicity</td>
<td><img src="green.png" alt="Green Circle" /></td>
<td><img src="orange.png" alt="Orange Circle" /></td>
<td><img src="red.png" alt="Red Circle" /></td>
</tr>
</tbody>
</table>

* 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 aneuploid/polyploid 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


Fiore, Mario & Mattiuozzo, 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.


Carbaryl

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

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

* 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


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.


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.

<table>
<thead>
<tr>
<th>General aspects</th>
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</thead>
<tbody>
<tr>
<td>Registered products containing Carbofuran</td>
</tr>
<tr>
<td>Manufacturing companies</td>
</tr>
<tr>
<td>HHP</td>
</tr>
<tr>
<td>Withdrawn in Europe</td>
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<tr>
<td>Crops treated</td>
</tr>
<tr>
<td>Pest</td>
</tr>
<tr>
<td>Alternatives*</td>
</tr>
</tbody>
</table>

### 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.
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


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

<table>
<thead>
<tr>
<th>Registered products containing Chlorpyrifos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agropyrifos 48 EC</td>
</tr>
<tr>
<td>Anaconda 55 EC</td>
</tr>
<tr>
<td>Antfex 48 EC</td>
</tr>
<tr>
<td>Betafos 263 EC, Buldock star EC 262.5</td>
</tr>
<tr>
<td>Cobra 75WG</td>
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<tr>
<td>Colt 480 EC</td>
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<tr>
<td>Cyren 480 EC</td>
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<tr>
<td>Dursban 4 EC</td>
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<tr>
<td>Epyrifos</td>
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<tr>
<td>Gladiator 4TC</td>
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<td>Glean 75 DF</td>
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<tr>
<td>Pyrinex quick 256 ZC</td>
</tr>
<tr>
<td>Ranger 48% EC</td>
</tr>
<tr>
<td>Reldan 40 EC</td>
</tr>
<tr>
<td>Robust 48 EC</td>
</tr>
<tr>
<td>Royalnex CS 25</td>
</tr>
<tr>
<td>Spectator Gold 500 EC</td>
</tr>
<tr>
<td>Sulban 48 EC</td>
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<tr>
<td>Trice 48 EC</td>
</tr>
<tr>
<td>Twigapyrifos 480EC</td>
</tr>
</tbody>
</table>

### Manufacturing companies

- 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.
- 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

### HHP

<table>
<thead>
<tr>
<th>Withdrawn in Europe</th>
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<tbody>
<tr>
<td>Yes</td>
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</table>

Withdrawn in Europe Yes
**Crops treated**
Barley, Maize, Wheat, Pineapples

**Pest**
Caterpillars, Termites, Ants, Aphids, Thrips, Whitefly, Bollworms, Antestia bugs, Armyworms, Mosquitoes larvae, Leaf miner, Mealy bugs

**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

<table>
<thead>
<tr>
<th>Human Health**</th>
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<tbody>
<tr>
<td>Carcinogenicity</td>
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<tr>
<td>Mutagenicity</td>
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<tr>
<td>Endocrine Disrupter</td>
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<tr>
<td>Reproductive Toxicity</td>
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<td>Neurotoxicity</td>
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<tr>
<th>Environmental Health**</th>
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<tbody>
<tr>
<td>Bee Toxicity</td>
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<td>Fish Toxicity</td>
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<tr>
<td>Earthworm Toxicity</td>
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<tr>
<td>Bird Toxicity</td>
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</table>

* 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


**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.

<table>
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<tr>
<th>General aspects</th>
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<tbody>
<tr>
<td>Registered products containing Deltamethrin</td>
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<tr>
<th>Manufacturing companies</th>
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<tbody>
<tr>
<td>Bayer Crop Science.</td>
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<tr>
<td>CongTy TNHH Alfa Vietnam</td>
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<tr>
<td>Sulphur Mills, India.</td>
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<tr>
<td>Tagros Chemicals, Ltd., India.</td>
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<td>Adama Makhteshim Ltd, Israel</td>
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<tr>
<td>Sichuan Saiwei Biological Engineering Co., Ltd., China</td>
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<th>HHP</th>
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<tr>
<th>Withdrawn in Europe</th>
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<tr>
<td>No</td>
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<table>
<thead>
<tr>
<th>Crops treated</th>
</tr>
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<tbody>
<tr>
<td>French Beans, Barley, Wheat, Maize, Citrus, Onions, Tomatoes, Cabbages, Peas, Broccoli, Cucumber, Pepper</td>
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<thead>
<tr>
<th>Pest</th>
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</thead>
<tbody>
<tr>
<td>Aphids, Thrips, Bollworms, Whiteflies, Weevils, Red flour beetle, Grain borer, Mealy bugs, Caterpillar, Spider mites, Diamond black moth</td>
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<tr>
<th>Alternatives*</th>
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<tr>
<td>Ozoneem, Achook, Nemroc (Azadirachtin), AMINEM XY16 Liquid Emulsion (Carvacrol 2% w/v), NEMguard® (Polysulphide Formulation)</td>
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<tr>
<td>Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur</td>
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<tr>
<td>Oxymatrine, pyrethroids</td>
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<tr>
<td>Endocrine Disrupter</td>
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<tr>
<td>Reproductive Toxicity</td>
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<tr>
<td>Neurotoxicity</td>
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</table>
Environmental Health**

<table>
<thead>
<tr>
<th>Toxicity</th>
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<th>Medium</th>
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<tbody>
<tr>
<td>Bee Toxicity</td>
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<tr>
<td>Fish Toxicity</td>
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<td>Earthworm Toxicity</td>
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<tr>
<td>Bird Toxicity</td>
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</table>

* 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 (Khalatbarry 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 (Heptasag 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


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 amazzonicus. Ecotoxicology and Environmental Contamination, 8: 59-64.


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).

<table>
<thead>
<tr>
<th>General aspects</th>
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</thead>
<tbody>
<tr>
<td>Registered products containing Gamma-Cyhalothrin</td>
</tr>
<tr>
<td>Manufacturing companies</td>
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<tr>
<td>HHP</td>
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<tr>
<td>Withdrawn in Europe</td>
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<tr>
<td>Crops treated</td>
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<tr>
<td>Pest</td>
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<tr>
<td>Alternatives*</td>
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**Human Health**

<table>
<thead>
<tr>
<th>Carcinogenicity</th>
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<tbody>
<tr>
<td>Mutagenicity</td>
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<td>Endocrine Disrupter</td>
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<tr>
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**Environmental Health**

<table>
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<th>Bee Toxicity</th>
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</table>

* 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).


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


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
Permethrin

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

<table>
<thead>
<tr>
<th>General aspects</th>
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<tbody>
<tr>
<td>Registered products containing Permethrin</td>
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<tr>
<td>Ambush 25 DC (formerly Permethrin 25WP)</td>
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<tr>
<td>Deraphon P 1%</td>
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<td>Dragnet FT</td>
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<td>Manufacturing companies</td>
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<tr>
<td>FMC Corporation, USA.</td>
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<td>Syngenta UK Ltd.</td>
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<td>United Phosphorous Ltd., India.</td>
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<td>Yes</td>
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<td>Withdrawn in Europe</td>
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<td>Yes</td>
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<tr>
<td>Crops treated</td>
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<tr>
<td>Maize</td>
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<tr>
<td>Pest</td>
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<tr>
<td>Large grain borer, Lesser grain borer, Angoumois grain moth, Maize weevils, Aphids</td>
</tr>
<tr>
<td>Alternatives*</td>
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<tr>
<td>Magneto, Nimbecidine, Trilogy (Azadirachtin)</td>
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* 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 (Carloni 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


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.


Weng et al., (2016). *Permethrin is Potential Thyroid – disrupting chemical: In vivo and in silico evidence.* Aquat Toxicol.


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  
 blended with insecticide  
 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


**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).

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Registered products containing Dimethoate</strong></td>
</tr>
<tr>
<td>Agrothoate 40 EC</td>
</tr>
<tr>
<td>Alphadime 85 Ulv</td>
</tr>
<tr>
<td>Danadim Blue 40 EC</td>
</tr>
<tr>
<td>Dimekil 40 EC</td>
</tr>
<tr>
<td>Domino 40 EC</td>
</tr>
<tr>
<td>Ethoate</td>
</tr>
<tr>
<td>Hangthoate 400 EC</td>
</tr>
<tr>
<td>Hygro 40% EC</td>
</tr>
<tr>
<td>Ogor 40 EC</td>
</tr>
<tr>
<td>Rogor L 40 EC</td>
</tr>
<tr>
<td>Tafgor 40 EC</td>
</tr>
<tr>
<td>Twigathoate 40% EC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Manufacturing companies</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Asiatic Agricultural Industries, Singapore.</td>
</tr>
<tr>
<td>Cheminova A/S, Denmark</td>
</tr>
<tr>
<td>Hyderabad Chemical Products Ltd. India.</td>
</tr>
<tr>
<td>Isagro SPA, Italy</td>
</tr>
<tr>
<td>Jiangsu Tenglong Biological &amp; Medical Co. Ltd., China/Hangzhou Jike Company Ltd., China</td>
</tr>
<tr>
<td>National Company for Agrochemicals Agrochem, Egypt</td>
</tr>
<tr>
<td>Novus-Bridge Consultants</td>
</tr>
<tr>
<td>Rallis Ltd., India.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>HHP</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Withdrawn in Europe</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Crops treated</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes, Coffee, Cotton, Tobacco</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Pest</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphids, Potato tuber moth, Thrips, Bollworms, Whiteflies, Caterpillars</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Alternatives</strong>*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ozoneem, Achook, Nemroc (Azadirachtin), AMINEM XY16 Liquid Emulsion (Carvacrol 2% w/v), NEMguard® (Polysulphide Formulation)</td>
</tr>
<tr>
<td>Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur</td>
</tr>
<tr>
<td>Oxymatrine, pyrethroids</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Human Health</strong>* **</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Carcinogenicity</strong></td>
<td>![Icon] ![Icon] ![Icon]</td>
</tr>
<tr>
<td><strong>Mutagenicity</strong></td>
<td>![Icon] ![Icon] ![Icon]</td>
</tr>
<tr>
<td><strong>Endocrine Disrupter</strong></td>
<td>![Icon] ![Icon] ![Icon]</td>
</tr>
<tr>
<td><strong>Reproductive Toxicity</strong></td>
<td>![Icon] ![Icon] ![Icon]</td>
</tr>
<tr>
<td><strong>Neurotoxicity</strong></td>
<td>![Icon] ![Icon] ![Icon]</td>
</tr>
</tbody>
</table>
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 (Mohananpriya, 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


### 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).

<table>
<thead>
<tr>
<th>General aspects</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered products containing</td>
<td>Belt 480 SC</td>
</tr>
<tr>
<td>Flubendiamide</td>
<td>Tihan OD 175</td>
</tr>
<tr>
<td>Manufacturing companies</td>
<td>Bayer AG Germany.</td>
</tr>
<tr>
<td></td>
<td>Nihon N.C Ltd, Germany; Bayer AG, Germany</td>
</tr>
<tr>
<td>HHP</td>
<td>Yes</td>
</tr>
<tr>
<td>Withdrawn in Europe</td>
<td>No</td>
</tr>
<tr>
<td>Crops treated</td>
<td>Cabbages, Tomatoes, Maize, Chilies, Potatoes, Broccoli</td>
</tr>
<tr>
<td>Pest</td>
<td>Diamond back moth, Caterpillars, Maize stalk borers, Armyworm, Aphids, Mealybugs, Thrips, Whiteflies</td>
</tr>
<tr>
<td>Alternatives*</td>
<td>-</td>
</tr>
<tr>
<td>Human Health**</td>
<td></td>
</tr>
<tr>
<td>Carcinogenicity</td>
<td><img src="green" alt="Green" /> <img src="orange" alt="Orange" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Mutagenicity</td>
<td><img src="green" alt="Green" /> <img src="orange" alt="Orange" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Endocrine Disrupter</td>
<td><img src="orange" alt="Orange" /> <img src="red" alt="Red" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
<td><img src="orange" alt="Orange" /> <img src="red" alt="Red" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Neurotoxicity</td>
<td><img src="green" alt="Green" /> <img src="orange" alt="Orange" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Environmental Health**</td>
<td></td>
</tr>
<tr>
<td>Bee Toxicity</td>
<td><img src="green" alt="Green" /> <img src="orange" alt="Orange" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Fish Toxicity</td>
<td><img src="orange" alt="Orange" /> <img src="red" alt="Red" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Earthworm Toxicity</td>
<td><img src="green" alt="Green" /> <img src="orange" alt="Orange" /> <img src="red" alt="Red" /></td>
</tr>
<tr>
<td>Bird Toxicity</td>
<td><img src="green" alt="Green" /> <img src="orange" alt="Orange" /> <img src="red" alt="Red" /></td>
</tr>
</tbody>
</table>

* **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 sensitiser (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


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.


Flufenoxuron

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

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered products containing Flufenoxuron</td>
</tr>
<tr>
<td>Manufacturing companies</td>
</tr>
<tr>
<td>HHP</td>
</tr>
<tr>
<td>Withdrawn in Europe</td>
</tr>
<tr>
<td>Crops treated</td>
</tr>
<tr>
<td>Pest</td>
</tr>
<tr>
<td>Alternatives*</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
</tr>
</tbody>
</table>

**Human Health**

- **Carcinogenicity**
  - [ ] low
  - [ ] medium
  - [ ] high

- **Mutagenicity**
  - [ ] low
  - [ ] medium
  - [ ] high

- **Endocrine Disrupter**
  - [ ] low
  - [ ] medium
  - [ ] high

- **Reproductive Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

- **Neurotoxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

**Environmental Health**

- **Bee Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

- **Fish Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

- **Earthworm Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

- **Bird Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

* 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**

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 hematocrit 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


Cho, Soon-Kil; Abd El-Aty, A.M.; Rahman, Md. Musfiqur; 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


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.


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

<table>
<thead>
<tr>
<th>Registered products containing Omethoate</th>
<th>Folimat 500 SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing companies</td>
<td>Arysta LifeScience Corporation, Japan.</td>
</tr>
<tr>
<td>HHP</td>
<td>Yes</td>
</tr>
<tr>
<td>Withdrawn in Europe</td>
<td>Yes</td>
</tr>
<tr>
<td>Crops treated</td>
<td>Coffee</td>
</tr>
<tr>
<td>Pest</td>
<td>-</td>
</tr>
<tr>
<td>Alternatives*</td>
<td>-</td>
</tr>
</tbody>
</table>

### Human Health**

<table>
<thead>
<tr>
<th>Carcinogenicity</th>
<th>![Green Circle] ![Orange Circle] ![Red Circle]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutagenicity</td>
<td>![Orange Circle] ![Red Circle]</td>
</tr>
<tr>
<td>Endocrine Disrupter</td>
<td>![Orange Circle] ![Red Circle]</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle]</td>
</tr>
<tr>
<td>Neurotoxicity</td>
<td>![Orange Circle] ![Red Circle]</td>
</tr>
</tbody>
</table>

### Environmental Health**

| Bee Toxicity             | ![Orange Circle] ![Red Circle]               |
| Fish Toxicity            | ![Orange Circle] ![Red Circle]               |
| Earthworm Toxicity       | ![Orange Circle] ![Red Circle]               |
| Bird Toxicity            | ![Green Circle] ![Orange Circle] ![Red Circle] |

* 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


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.

### 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
- Gall 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

### General aspects

- Adama Makhteshim Ltd, Israel
- Anhui Fengle Agrochemical Co Ltd, China
- Bayer AG Germany, Leverkusen, Germany
### Manufacturing companies

- 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 Agroscience 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 Jiadelhi Technical Development Co Ltd, China
- Sineria China Chemical Ltd China
- Topsen Goldchance Fluence, China/ Sineria Industries Ltd, Cyprus
- UPL Limited India

### HHP

Yes

### Withdrawn in Europe

Yes

### Crops treated

- French beans, Maize, Citrus, Snow peas, Cabbages,

### Pest

- Aphids, Whiteflies, Thrips, Bean flies, Beetles, Leaf miners

### Alternatives*

- Fortune, Magneto, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin), Pesthrin, Pyagro, Pyeneem Oxymatrine products: Peril, Levo
- Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Sulphur
- Oxymatrine, pyrethroids

### Human Health**

| Carcinogenicity |  
| Mutagenicity |  
| Endocrine Disrupter |  
| Reproductive Toxicity |  
| Neurotoxicity |  

### Environmental Health**

| Bee Toxicity |  

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, neurotoxicity 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 testes 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 (Kipkemoi et al., 2021).
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 bioaccumulation (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


Fossen, M., (2006). Environmental Fate of Imidacloprid; California Department of Pesticide Regulation, Environmental Monitoring: Sacramento, CA,


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


**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.

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Registered products containing Thiacloprid</strong></td>
</tr>
<tr>
<td>Calypso SC 480</td>
</tr>
<tr>
<td><strong>Manufacturing companies</strong></td>
</tr>
<tr>
<td>Bayer AG Germany.</td>
</tr>
<tr>
<td><strong>HHP</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td><strong>Withdrawn in Europe</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td><strong>Crops treated</strong></td>
</tr>
<tr>
<td>Chilies, Eggplants, Tomatoes, Onions</td>
</tr>
<tr>
<td><strong>Pest</strong></td>
</tr>
<tr>
<td>Aphids, Whiteflies, Thrips, Mealybugs, Spidermites, Caterpillars</td>
</tr>
<tr>
<td><strong>Alternatives</strong>*</td>
</tr>
<tr>
<td>Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadiractin)</td>
</tr>
<tr>
<td><strong>Alternatives</strong></td>
</tr>
<tr>
<td>Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Pyriproxifen, Sulphur</td>
</tr>
<tr>
<td>Oxymatrine, pyrethroids</td>
</tr>
</tbody>
</table>

**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


Sekeroglu V, Atli S, ekeroglu 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).

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dera Blue Cross</td>
</tr>
<tr>
<td>Dera Blue Cross Dust</td>
</tr>
<tr>
<td>Dera Malathion 50 EC</td>
</tr>
<tr>
<td>Fedothion 50 EC</td>
</tr>
<tr>
<td>Fyfanon 50EC</td>
</tr>
<tr>
<td>Magic 50 EC</td>
</tr>
<tr>
<td>Nova Super Blue Cross</td>
</tr>
<tr>
<td>Nova Super Blue Cross Dust</td>
</tr>
<tr>
<td>Oshothion 50 EC</td>
</tr>
<tr>
<td>Permal Dust</td>
</tr>
<tr>
<td>Skana Super Grain Dust</td>
</tr>
<tr>
<td>Super Blue Cross Dust</td>
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<tr>
<td>Super Malper Dust</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Registered products containing Malathion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bharat Insecticide Ltd., India</td>
</tr>
<tr>
<td>Cheminova AS, Denmark</td>
</tr>
<tr>
<td>Dera Chemical Industries (K) Ltd.</td>
</tr>
<tr>
<td>Sulphur Mills India</td>
</tr>
<tr>
<td>Sulphur Mills, India. / Osho Chemical Industries Ltd.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manufacturing companies</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crops treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kales, Beans, Tomatoes, French beans, Grains, Cabbages, Avocados</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphids, Diamond black moth, Whiteflies, Russet mites, Weevils, Larger grain borer, Caterpillars, Fruit flies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternatives*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem, Neemark, Achook (Azadirachtin)</td>
</tr>
<tr>
<td>Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram, Spinosad, Flubendiamide, Pyriproxifen, Sulphur</td>
</tr>
<tr>
<td>Oxymatrine, pyrethroids</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Human Health**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinogenicity</td>
</tr>
<tr>
<td>Mutagenicity</td>
</tr>
<tr>
<td>Endocrine Disrupter</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
</tr>
<tr>
<td>Neurotoxicity</td>
</tr>
</tbody>
</table>
### Environmental Health**

<table>
<thead>
<tr>
<th>Bee Toxicity</th>
<th>Fish Toxicity</th>
<th>Earthworm Toxicity</th>
<th>Bird Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Green Circle" /></td>
<td><img src="image2" alt="Orange Circle" /></td>
<td><img src="image3" alt="Green Circle" /></td>
<td><img src="image4" alt="Red Circle" /></td>
</tr>
</tbody>
</table>

* 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 organothiophosphates 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 (Vayssière 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


PESTICIDES IN THE KENYAN MARKET


# Pymetrozine

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

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Registered products containing Pymetrozine</strong></td>
</tr>
<tr>
<td>Chess 50 WG Water</td>
</tr>
<tr>
<td>Fulfil 25SC</td>
</tr>
<tr>
<td><strong>Manufacturing companies</strong></td>
</tr>
<tr>
<td>Hailir Pesticides &amp; Chemicals Group Co Ltd, China</td>
</tr>
<tr>
<td>Syngenta AG, Basle, Switzerland.</td>
</tr>
<tr>
<td><strong>HHP</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td><strong>Withdrawn in Europe</strong></td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td><strong>Crops treated</strong></td>
</tr>
<tr>
<td>Cabbages, French beans, Kales, Beans</td>
</tr>
<tr>
<td><strong>Pest</strong></td>
</tr>
<tr>
<td>Aphids, Whiteflies, Thrips</td>
</tr>
<tr>
<td><strong>Alternatives</strong>*</td>
</tr>
<tr>
<td>Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem,</td>
</tr>
<tr>
<td>Neemark, Achook (Azadirachtin)</td>
</tr>
<tr>
<td>Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram,</td>
</tr>
<tr>
<td>Spinosad, Flubendiamide, Pyriproxifen, Sulphur</td>
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</table>

### Human Health**

<table>
<thead>
<tr>
<th>Carcinogenicity</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
<tr>
<td>Mutagenicity</td>
</tr>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
<tr>
<td>Endocrine Disrupter</td>
</tr>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
</tr>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
<tr>
<td>Neurotoxicity</td>
</tr>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
</tbody>
</table>

### Environmental Health**

<table>
<thead>
<tr>
<th>Bee Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
<tr>
<td>Fish Toxicity</td>
</tr>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
<tr>
<td>Earthworm Toxicity</td>
</tr>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
<tr>
<td>Bird Toxicity</td>
</tr>
<tr>
<td><img src="green.png" alt="Low" /> <img src="orange.png" alt="Medium" /> <img src="red.png" alt="High" /></td>
</tr>
</tbody>
</table>

* 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


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.

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered products containing Oxydemeton-methyl</td>
</tr>
<tr>
<td>Metasystox</td>
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<tr>
<td>Hattrick EC</td>
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<tr>
<td>Manufacturing companies</td>
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<tr>
<td>United Phosphorus India</td>
</tr>
<tr>
<td>Orbit Agro Chemical Industries Ltd.</td>
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<tr>
<td>HHP</td>
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<tr>
<td>Yes</td>
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<tr>
<td>Withdrawn in Europe</td>
</tr>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>Crops treated</td>
</tr>
<tr>
<td>Citrus, Wheat, Potatoes, Maize, Barley</td>
</tr>
<tr>
<td>Pest</td>
</tr>
<tr>
<td>Aphids, Thrips, Red Spidermites, Whiteflies</td>
</tr>
<tr>
<td>Alternatives*</td>
</tr>
<tr>
<td>Fortune, Magneto, Neemroc, Nimbecidine, Ozoneem,</td>
</tr>
<tr>
<td>Neemark, Achook (Azadirachtin)</td>
</tr>
<tr>
<td>Diflubenzuron, Spirotetramat, Acrinathrin, Spinetoram,</td>
</tr>
<tr>
<td>Spinosad, Flubendiamide, Pyriproxifen, Sulphur</td>
</tr>
<tr>
<td>Oxymatrine, pyrethroids</td>
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</tbody>
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**Human Health**

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<th></th>
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<tbody>
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<td>Carcinogenicity</td>
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<td>![high]</td>
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<tr>
<td>Mutagenicity</td>
<td>![low]</td>
<td>![medium]</td>
<td>![high]</td>
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<tr>
<td>Endocrine Disrupter</td>
<td>![low]</td>
<td>![medium]</td>
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<tr>
<td>Reproductive Toxicity</td>
<td>![low]</td>
<td>![medium]</td>
<td>![high]</td>
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<tr>
<td>Neurotoxicity</td>
<td>![low]</td>
<td>![medium]</td>
<td>![high]</td>
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**Environmental Health**

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<tr>
<td>Bee Toxicity</td>
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<tr>
<td>Fish Toxicity</td>
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<tr>
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<td>![low]</td>
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<tr>
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<td>![low]</td>
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</tbody>
</table>

* 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). Oxydementon-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


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

<table>
<thead>
<tr>
<th>Registered products containing Chlorothalonil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amizoc 480 SC</td>
</tr>
<tr>
<td>Bravo TOP 550SC</td>
</tr>
<tr>
<td>Cherokee 487.5 SE</td>
</tr>
<tr>
<td>Clortocaffaro WP</td>
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<tr>
<td>Clortosip 75 WP</td>
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<tr>
<td>Compliant 560 SC</td>
</tr>
<tr>
<td>Dakonil 720SC (Bravo 720 SC)</td>
</tr>
<tr>
<td>Dakota 50 FW</td>
</tr>
<tr>
<td>Folio Gold 537.5 SC</td>
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<tr>
<td>Glider 720 SC</td>
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<tr>
<td>Katerina 720 SC</td>
</tr>
<tr>
<td>Koban</td>
</tr>
<tr>
<td>Noxnil 72 SC</td>
</tr>
<tr>
<td>Odeon 82.5</td>
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<tr>
<td>Providence 400 WP</td>
</tr>
<tr>
<td>Rankonil 500 SC</td>
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<tr>
<td>Rova 500SC</td>
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<tr>
<td>Rova 75 WP</td>
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<tr>
<td>Twiga Eponil 600 SC</td>
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<tr>
<td>Twigathalonil 720SC</td>
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</tbody>
</table>

### Manufacturing companies

- Adama Makhteshim Ltd, Israel.
- Arysta LifeScience SAS, France.
- Calliope S. A. S, France.
- Jiangsu Xinhe Agrochemical Co., Ltd
- Jiangyin Sulfine Chemicals, China.
- Jiansu Suli Chemicals Co Ltd, China.
- Ningbo Sunjoy Agroscience 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, Benalaxyl-M, Dimethomorph
Human Health**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>Carcinogenicity</td>
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<tr>
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<tr>
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Environmental Health**

<table>
<thead>
<tr>
<th>Effect</th>
<th>Low</th>
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<tr>
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<tr>
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</tbody>
</table>

* 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
PESTICIDES IN THE KENYAN MARKET

References


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).

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goddard 35 SE</td>
</tr>
<tr>
<td>Seed Pro 30 WS</td>
</tr>
<tr>
<td>Saaf WP</td>
</tr>
<tr>
<td>Sherrif 75 WP</td>
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<tr>
<td>Megaprode Lock 52.5 WP</td>
</tr>
<tr>
<td>Rimeta Gold 300 SC</td>
</tr>
<tr>
<td>Discovery 400 SC</td>
</tr>
<tr>
<td>Bendazim 500 SC</td>
</tr>
<tr>
<td>Botran 500 SC</td>
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<tr>
<td>Chariot 500 SC</td>
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<tr>
<td>Rodazim SC</td>
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<tr>
<td>Ransom 600WP</td>
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<tr>
<td>Pearl 80 DF</td>
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<tr>
<td>Exempo-Curve 250 SC</td>
</tr>
<tr>
<td>Soprano SC 250</td>
</tr>
<tr>
<td>Seed Plus 30WS</td>
</tr>
<tr>
<td>Companion 75 WP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Registered products containing Carbendazim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adama Makhteshim Ltd, Israel.</td>
</tr>
<tr>
<td>Anhui Guangxin Agrochemical Co. Ltd., China/ Ningbo</td>
</tr>
<tr>
<td>Sunjoy Agroscience Co. Ltd, China</td>
</tr>
<tr>
<td>Indofil Industries Limited, India</td>
</tr>
<tr>
<td>Jiangsu Kuaida Agrochemical Ltd, China</td>
</tr>
<tr>
<td>Ningbo Yihwei Chemical Co. Ltd., China</td>
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<tr>
<td>Rotam Agrochemicals, Hong Kong.</td>
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<tr>
<td>Shaanxi Hengrun Chemical Industry Co. Ltd, China</td>
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<tr>
<td>Shanghai Forever Chemicals Co. Ltd., China</td>
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<tr>
<td>Sulphur Mills Ltd., India.</td>
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<td>Topsen Goldchance Fluence, China/ Sineria Industries Ltd, Cyprus</td>
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<tr>
<td>UPL Ltd, India</td>
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<td>Yantai Keda Chemical Co. Ltd China</td>
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<tr>
<th>Manufacturing companies</th>
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<tbody>
<tr>
<td>Yes</td>
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</table>

<table>
<thead>
<tr>
<th>Withdrawn in Europe</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
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</table>

<table>
<thead>
<tr>
<th>Crops treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>French beans, Snow beans, Mangoes, Citrus, Pawpaw, Tomatoes, Rice, Capsicum</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>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</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternatives*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bupirimate, Sulphur, Captan, Thiophanate-Methyl, Trifloxystrobin, Azoxystrobin, Prothioconazole, Benalaxyl-M, Dimethomorph</td>
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</table>
### Human Health**

<table>
<thead>
<tr>
<th>Category</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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<tr>
<td>Carcinogenicity</td>
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<tr>
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<tr>
<td>Neurotoxicity</td>
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### Environmental Health**

<table>
<thead>
<tr>
<th>Category</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bee Toxicity</td>
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<td>Fish Toxicity</td>
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<td>Earthworm Toxicity</td>
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<tr>
<td>Bird Toxicity</td>
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</tbody>
</table>

* 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, endocrine-disrupting effects, endocrine-disrupting effects, disruption of haematological functions, mitotic spindle abnormal (Rama et al., 2014; Salihu 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


**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  
| | Jiangu 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, Benalyaxl-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 sensitiser 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


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.


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**

<table>
<thead>
<tr>
<th>Registered products containing Mancozeb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrobat 69% MZ</td>
</tr>
<tr>
<td>Agrilax 72 WP</td>
</tr>
<tr>
<td>Agrithane WP</td>
</tr>
<tr>
<td>Agromax MZ 720 WP</td>
</tr>
<tr>
<td>Amimax 720WP</td>
</tr>
<tr>
<td>Belthane 80 WP</td>
</tr>
<tr>
<td>Biothane 80WP</td>
</tr>
<tr>
<td>Bonus 72WP</td>
</tr>
<tr>
<td>Cadilac 80WP</td>
</tr>
<tr>
<td>Companion 75 WP</td>
</tr>
<tr>
<td>Corum 72% W</td>
</tr>
<tr>
<td>Curzate M 44 WP</td>
</tr>
<tr>
<td>Dithane Dg, Rainshield</td>
</tr>
<tr>
<td>Dithane M-45</td>
</tr>
<tr>
<td>Dithchem 80 WP</td>
</tr>
<tr>
<td>Emalaxyl 68 WP</td>
</tr>
<tr>
<td>Emthane-45 WP</td>
</tr>
<tr>
<td>Envy 72 WP</td>
</tr>
<tr>
<td>Eureka 80 WP</td>
</tr>
<tr>
<td>Fantic M 4-65 WG</td>
</tr>
<tr>
<td>Farmcozeb 75WG</td>
</tr>
<tr>
<td>Farmmil 72 WP</td>
</tr>
<tr>
<td>Fortress gold 72 WP</td>
</tr>
<tr>
<td>Forum 690 WP</td>
</tr>
<tr>
<td>Galben M8-65</td>
</tr>
<tr>
<td>Globe 76 WP</td>
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<tr>
<td>Hanthane 80</td>
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<tr>
<td>Indofil M45 WP</td>
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<td>Ivory 80 WP</td>
</tr>
<tr>
<td>Kenthane 80 WP</td>
</tr>
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<td>Lavida 73 WDG</td>
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<td>Mancobex 80WP</td>
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<tr>
<td>Mancoflo 455SC</td>
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<td>Mancolax WP</td>
</tr>
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<tr>
<td>Metacozeb 72</td>
</tr>
<tr>
<td>Micene 76WP</td>
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<tr>
<td>Millionaire 69% WDG</td>
</tr>
<tr>
<td>Novazeb 80</td>
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<tr>
<td>Novithane 80 WP</td>
</tr>
<tr>
<td>Oshothane Plus WDG</td>
</tr>
<tr>
<td>Penncozeb 80</td>
</tr>
<tr>
<td>Pyramid 700 WP</td>
</tr>
<tr>
<td>Saaf WP</td>
</tr>
<tr>
<td>Samurai 72 WP</td>
</tr>
<tr>
<td>Sancobez 80 WP</td>
</tr>
<tr>
<td>Senator 80 WP</td>
</tr>
<tr>
<td>Sherrif 75 WP</td>
</tr>
<tr>
<td>Skipper 720 WP</td>
</tr>
<tr>
<td>Registered products containing Mancozeb</td>
</tr>
<tr>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Miltanhe Super</td>
</tr>
<tr>
<td>Mistress 72 WP</td>
</tr>
<tr>
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</tr>
<tr>
<td>Mosthan 80</td>
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<td>Murthane 80</td>
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<td>Pyramid 700 WP</td>
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<tr>
<td>Saaf WP</td>
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<td>Sancobez 80 WP</td>
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<td>Senator 80 WP</td>
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<td>Sherrif 75 WP</td>
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<tr>
<td>Skipper 720 WP</td>
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<td>Stargem 80 WP</td>
</tr>
<tr>
<td>Tajiri 72WP</td>
</tr>
<tr>
<td>Tata master</td>
</tr>
<tr>
<td>Topstar 72 WP</td>
</tr>
<tr>
<td>Tower 72 WP</td>
</tr>
<tr>
<td>Tridex 80 WP</td>
</tr>
<tr>
<td>Trinity Gold 452 Wettatable powder</td>
</tr>
<tr>
<td>Tigaalaxyl 72% WP</td>
</tr>
<tr>
<td>Ugonall 580 WP</td>
</tr>
<tr>
<td>Upron 72WP</td>
</tr>
<tr>
<td>Uthane WP</td>
</tr>
<tr>
<td>Vidalia 69WP</td>
</tr>
<tr>
<td>Vondozeb 75 DG</td>
</tr>
<tr>
<td>Zeblight 80 WP</td>
</tr>
<tr>
<td>Zetanil 76 WP</td>
</tr>
</tbody>
</table>

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

- 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

<table>
<thead>
<tr>
<th>HHP</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withdrawn in Europe</td>
<td>Yes</td>
</tr>
<tr>
<td>Crops treated</td>
<td>Tomatoes, Potatoes, French beans, Cabbages, Onions</td>
</tr>
<tr>
<td>Pest</td>
<td>Early and late blight, Downy mildew, Rust, Botrytis, Angular leaf spot</td>
</tr>
<tr>
<td>Alternatives*</td>
<td>Bupirimate, Sulphur, Captan, Thiophanate-Methyl, Trifloxystrobin, Azoxystrobin, Prothioconazole, Benalyaxl-M, Dimethomorph</td>
</tr>
</tbody>
</table>

#### Human Health**

- **Carcinogenicity**
  - [ ] low
  - [ ] medium
  - [ ] high
- **Mutagenicity**
  - [ ] low
  - [ ] medium
  - [ ] high
- **Endocrine Disrupter**
  - [ ] low
  - [ ] medium
  - [ ] high
- **Reproductive Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high
- **Neurotoxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

#### Environmental Health**

- **Bee Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high
- **Fish Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high
- **Earthworm Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high
- **Bird Toxicity**
  - [ ] low
  - [ ] medium
  - [ ] high

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* 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

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### 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,
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


**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

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

### 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
- Shandong Worldwide Exports Pvt. Ltd; Registrant: Sineria (Industries) Ltd Cyprus
- Jiangsu Sevencontinent Green Chemical Co., Ltd., China
- Shandong Sino-Agrí United Biotechnology Co. Ltd, China
- Ningbo Yihwei Co. Ltd., China
- Ningbo Sunjoy Agroscience Co. Ltd., China
- Astec Lifesciences
- Adama Makhteshim. Ltd, Israel
- Shandong Sino-Agrí United Biotechnology Co. Ltd, China
- Shandong 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.
HHP
Yes

Withdrawn in Europe
No

Crops treated
Mangoes, Maize, Beans, French beans, Barley, Wheat, Cabbages

Pest
Yellow and stem rust, Septoria, Powdery mildew, Anthracnose, Net blotch, Ring spot, Fusarium species, Spot blotch

Alternatives*
Bupirimate, Sulphur, Captan, Thiophanate-Methyl, 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

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 in 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


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.

<table>
<thead>
<tr>
<th>General aspects</th>
<th>AGRIMINE 2,4 D 720 SL</th>
<th>KEN 2,4D 720 SL</th>
<th>PRO 2.4D 720 SL</th>
<th>SINE 4 D 720 SL</th>
<th>AGROMINE 860 SL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered products containing 2,4-D Amine</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>Nanjing Agrochemicals Co., Ltd</td>
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<tr>
<td>HHP</td>
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<td></td>
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</tr>
<tr>
<td>Withdrawn in Europe</td>
<td>No</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Crops treated</td>
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<tr>
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<td>Weeds</td>
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<tr>
<td>Alternatives*</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 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

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 (Shahrebabak 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 Innov-
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


EFSA. (2018). Peer review of the pesticide risk assessment of the active substance (EZ)-1,3-dichloropropene. EFSJ, 16(11), e5464,29


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.


**Clodinafop**

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

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

* 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


**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.

<table>
<thead>
<tr>
<th>General aspects</th>
</tr>
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<tbody>
<tr>
<td>ZOOMER COMBI 390 SC</td>
</tr>
<tr>
<td>GALAXY 340 EC</td>
</tr>
<tr>
<td>PREDATOR 340 EC</td>
</tr>
<tr>
<td>OXYFEN 240 EC</td>
</tr>
<tr>
<td>OXYGOLD 24</td>
</tr>
<tr>
<td>WEEDMAX 240 EC</td>
</tr>
<tr>
<td>COMMANDER 240 EC</td>
</tr>
<tr>
<td>GALIGAN 240 EC</td>
</tr>
<tr>
<td>OXYCLEAN 240 EC</td>
</tr>
<tr>
<td>GOAL SUPREME 480 SC</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Registered products containing Oxyfluorfen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adama Agan LTD Israel</td>
</tr>
<tr>
<td>Ningbo Sunjoy Agroscience Ltd, China</td>
</tr>
<tr>
<td>Shandong Huayang Pesticide Chemical Industry Group Co., Ltd., China</td>
</tr>
<tr>
<td>Yifan Biotechnology Group Co. Ltd, China</td>
</tr>
<tr>
<td>Huili Import &amp; Export Company Limited, China</td>
</tr>
<tr>
<td>Shandong Qiaochang Modern Agriculture Co.Ltd, China</td>
</tr>
<tr>
<td>Zhejiang Yifan Chemical Co. Ltd</td>
</tr>
<tr>
<td>Shaanxi Sunger Road Bio-Science Co. Ltd, China</td>
</tr>
<tr>
<td>Shangyu Nutrichem Co Ltd, China</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Manufacturing companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adama Agan LTD Israel</td>
</tr>
<tr>
<td>Ningbo Sunjoy Agroscience Ltd, China</td>
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<td>Shangyu Nutrichem Co Ltd, China</td>
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<table>
<thead>
<tr>
<th>HHP</th>
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</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Withdrawn in Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crops treated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbages, Broccoli, Onions, Tomatoes, Pineapples</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grasses, Broad-leaved weeds, Grass weeds</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alternatives*</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Human Health**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcinogenicity</td>
</tr>
<tr>
<td>Mutagenicity</td>
</tr>
<tr>
<td>Endocrine Disrupter</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
</tr>
<tr>
<td>Neurotoxicity</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Health**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bee Toxicity</td>
</tr>
<tr>
<td>Fish Toxicity</td>
</tr>
</tbody>
</table>
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 (Megdoua 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


Glufosinate-ammonium

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

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

**Human Health**

<table>
<thead>
<tr>
<th>Carcinogenicity</th>
<th>![Green Circle] ![Orange Circle] ![Red Circle] ![Red Circle]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mutagenicity</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle] ![Red Circle]</td>
</tr>
<tr>
<td>Endocrine Disrupter</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle] ![Red Circle]</td>
</tr>
<tr>
<td>Reproductive Toxicity</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle] ![Red Circle]</td>
</tr>
<tr>
<td>Neurotoxicity</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle] ![Red Circle]</td>
</tr>
</tbody>
</table>

**Environmental Health**

<table>
<thead>
<tr>
<th>Bee Toxicity</th>
<th>![Green Circle] ![Orange Circle] ![Red Circle] ![Green Circle]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish Toxicity</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle] ![Green Circle]</td>
</tr>
<tr>
<td>Earthworm Toxicity</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle] ![Green Circle]</td>
</tr>
<tr>
<td>Bird Toxicity</td>
<td>![Green Circle] ![Orange Circle] ![Red Circle] ![Green Circle]</td>
</tr>
</tbody>
</table>

* 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 in 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


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

<table>
<thead>
<tr>
<th>Wildlife toxicity (Bees, fish) [mg/L]</th>
<th>Chronic human health</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very toxic</td>
<td>Yes</td>
</tr>
<tr>
<td>Toxic</td>
<td>Possible</td>
</tr>
<tr>
<td>Moderately toxic</td>
<td>No</td>
</tr>
<tr>
<td>Low toxic</td>
<td>No data</td>
</tr>
<tr>
<td>Not toxic</td>
<td>Endocrine disruption</td>
</tr>
</tbody>
</table>

#### Wildlife toxicity (Bees, fish) [mg/L]
- **Very toxic**: Toxicity <0.1
- **Toxic**: Toxicity 0.1 - 1.0
- **Moderately toxic**: Toxicity 1.0 - 10
- **Low toxic**: Toxicity 10 - 100
- **Not toxic**: Toxicity >100

#### Chronic human health
- **Yes**: Carcinogenicity
- **Possible**: Mutagenicity
- **No**: Reproduction Toxicity
- **No data**: Neurotoxicity
- **Endocrine disruption**

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

<table>
<thead>
<tr>
<th>Mobility (solubility, persistence)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.8</td>
<td>High mobility</td>
</tr>
<tr>
<td>2.8-1.8</td>
<td>Medium</td>
</tr>
<tr>
<td>&lt;1.8</td>
<td>Low</td>
</tr>
<tr>
<td>No KOC or DT50 value</td>
<td>No data</td>
</tr>
</tbody>
</table>

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

**Environment**

- **Bees, fish, etc**
  - Toxicity <0.1: Value 4
  - Toxicity 0.1 - 1.0: Value 3
  - Toxicity 1.0 - 10: Value 2
  - Toxicity 10 - 100: Value 1
  - Toxicity >100: Value 0
  - No data: Value 2

**Mobility (solubility, persistence)**

- Toxicity <2.8: Value 4
- Toxicity 2.8 - 1.8: Value 2
- Toxicity <1.8: Value 1
- No data: Value 1.5

#### Human Health

**Endocrine Disrupting Acitity**

- Yes: Value 8
- Possible: Value 6
<table>
<thead>
<tr>
<th>Category</th>
<th>Yes</th>
<th>Possible</th>
<th>No data</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endocrine Disrupting Acidity</td>
<td>No data</td>
<td>3</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Carcinogenicity</td>
<td>Yes</td>
<td>8</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Possible</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No data</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mutagenicity</td>
<td>Yes</td>
<td>6</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Possible</td>
<td>4</td>
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<tr>
<td></td>
<td>No data</td>
<td>2</td>
<td></td>
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<tr>
<td></td>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproduction</td>
<td>Yes</td>
<td>4</td>
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<td>Possible</td>
<td>2</td>
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<tr>
<td></td>
<td>No</td>
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<tr>
<td>Neurotoxicity</td>
<td>Yes</td>
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<td>0</td>
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<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>Environmental score</th>
<th>Human Health Score</th>
<th>Total Score</th>
<th>Proposed Action in Kenya</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permethrin</td>
<td>17</td>
<td>24</td>
<td>41</td>
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</tr>
<tr>
<td>Bifenthrin</td>
<td>16</td>
<td>24</td>
<td>40</td>
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</tr>
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<td>22</td>
<td>36</td>
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</tr>
<tr>
<td>Dichlorvos</td>
<td>12</td>
<td>23</td>
<td>35</td>
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</tr>
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<td>Carbaryl</td>
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<td>20</td>
<td>34</td>
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</tr>
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<td>Carbendazim</td>
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<td>22</td>
<td>33</td>
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</tr>
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<td>Chlorothalonil</td>
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<td>33</td>
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</tr>
<tr>
<td>Chlorpyrifos</td>
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<td>14</td>
<td>33</td>
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</tr>
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<td>18</td>
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<td>32</td>
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<td>31</td>
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<td>16</td>
<td>27</td>
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</tr>
<tr>
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<td>16</td>
<td>27</td>
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</tr>
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</tr>
<tr>
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<tr>
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