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Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade

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Item 5 (c) (ix) of the provisional agenda**

Technical work: review of notifications of final regulatory action: paraquat

Paraquat: supporting documentation provided by Mozambique

Note by the Secretariat

As is mentioned in the note by the Secretariat on paraquat: notifications of final regulatory action (UNEP/FAO/RC/CRC.18/13), the annex to the present note sets out documentation provided by Mozambique to support its notification of final regulatory action for paraquat in the pesticide category. The present note, including its annex, has not been formally edited.

* Reissued for technical reasons on 29 July 2022.

** UNEP/FAO/RC/CRC.18/1.

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Annex

Paraquat: supporting documentation provided by Mozambique

List of documents:

1. Deliberacao Nr. 001/DNSA/2014 - National Directorate of Agriculture and Agrarian Services (The Pesticide Register Authority) in Portuguese and English.
2. Come A.M. & van der Valk H., 2014. Step 1 – Shortlisting highly hazardous pesticides Consultancy report undertaken under the Project EP/MOZ/101/UEP – Reducing Risks of Highly Hazardous Pesticides in Mozambique.
3. Come A.M.; Dona L.L.; Mancini F. & van der Valk H., 2014. Step 2 – Survey of pesticide use practices in selected cropping systems.
4. Come A.M. & van der Valk H., 2014. Step 4 – Occupational risk assessments.
5. FAO/WHO (2008) Report of the 2nd Joint Meeting on Pesticide Management and the 4th Session of the FAO Panel of Experts on Pesticide Management. 6-8 October 2008, Geneva. Food and Agriculture Organization of the United Nations, Rome & World Health Organization, Geneva. http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Code/Report.pdf (p.14 – 18).
6. Lahr J., R. Kruijne & J. Groenwold, 2014. Hazards of pesticides imported into Mozambique, 2002-2011. Wageningen, Alterra Wageningen UR (University & Research centre).
7. FAO/WHO, JMPR evaluation on Paraquat, 2004. http://www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/JMPR/Evaluation04/paraquat.pdf.
8. Pesticides Properties Database (PPDB): https://sitem.herts.ac.uk/aeru/ppdb/en/Reports/505.htm (abstract) Lewis, K.A., Tzilivakis, J., Warner, D. and Green, A. (2016) An international database for pesticide risk assessments and management. Human and Ecological Risk Assessment: An International Journal, 22(4), 1050-1064. DOI: 10.1080/10807039.2015.1133242.

República de Moçambique

MINISTÉRIO DA AGRICULTURA
DIRECÇÃO NACIONAL DE SERVIÇOS AGRÁRIOS

Deliberação Nº 001/DNSA/2014

OS pesticidas são produtos usados para a preservação das culturas e seus produtos contra diferentes pragas. Estes produtos, são por sua natureza tóxica e o uso indevido do mesmo pode perigar a saúde Humana, Animal e danificar o meio ambiente. Deste grupo de químicos, existem alguns que são considerados Altamente Perigoso. O Projecto de Redução dos de Riscos de Pesticidas Altamente Perigosos identificou os Pesticidas Altamente Perigosos que estão registados em Moçambique e depois de auscultar diferentes intervenientes (sector público, sector privado, sociedade civil e outros) conclui-se que para alguns deles dever-se-ia fazer o cancelamento imediato do registo e consequente não aprovação do seu uso em Moçambique e para outros o registo deveria ser cancelado no final do ano. Existe um outro grupo que carece de maior análise antes da tomada de decisão.

Desta forma e usando das competências atribuídas no artigo 3, coadjuvado com o artigo 1 e 4 de Decreto 6/2009 de 31 de Março a DNSA determina:

1. O Cancelamento imediato de todos os pesticidas que contenham as seguintes substâncias activas:

    a. Alachlor
    b. Aldicarb
    c. Carbendazim
    d. Carbofuran
    e. Diafenthiuron
    f. Diazinon (> 300 g/L)
    g. Diclofop–methyl
    h. Difenacoum
    i. Ethion
    j. Fenamiphos
    k. Iprodione
    l. Furfural
    m. Methidathion
    n. Methiocarb
    o. Monocrotophos
    p. Terbufos

DNSA-Rua da Resistência,Nr. 1746, Segundo Andar E-mail- dnsa.minag@gmail.com
Endereço Postal: DNSA, Caixa Postal 2272, Maputo-Moçambique;
Fax: (258)21 415103, Telefone: (258) 21415110

q. Thiodicarb
r. Zinc phosphide
s. Brodifacoum (formulações líquidas – 0.75 & 2.5 g/L)
t. Difethialone
u. Methamidophos
v. Benomyl
w. Methomyl 900 g/kg
x. Chlorfenvinphos
y. Carbaryl
z. Oxyfluorfen

2. Cancelamento à 31 de Dezembro de 2014 de todos os produtos que contenham as substâncias activas:

   a. 2,4-D dimethylamine
   b. Paraquat
   c. Endosulfão
   d. Diuron

3. Os produtos que contenham as substâncias activas listadas nos números 1 e 2 importados antes do cancelamento dos mesmos podem continuar a ser usados estando dentro do prazo de validade.

Maputo aos 15 de Julho de 2014

O Director Nacional

Mahomed Rafik Valá
(Tecnico Superior Agro-Pec de N1)

KC/19/10/2014

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Republic de Mozambique

MINISTRY OF AGRICULTURE

N N. 00I / DNSA / 2014

National Directorate of Agrarian Services

Deliberation N. 00I / DNSA / 2014

Pesticides are products used for the protection of crops and their products against different pests.

These products are by their nature toxic and their improper use can damage human health, animal health and damage the environment. among this group of chemicals, there are some that are considered Highly Hazardous. The project of Risk Reduction of Highly Hazardous Pesticides identified Highly Hazardous Pesticides that are registered in Mozambique and after consulting with different actors (public sector, private sector, civil society and others) it has been concluded that: for some of them the immediate cancellation of registration and consequent non-approval of their use in Mozambique should be done while for others the registration should be cancelled at the end of the year. There is another group for which further analysis is needed before taking the decision

In this way and using the competences assigned by article 3, in conjunction with article I and 4 of Decree 6/2009 of March 31, DNSA determines:

l. The immediate cancellation of all pesticides containing the following active substances:

Alachlor
Aldicarb
Carbendazim
Carbofuran
Diafenthiuron
Diazinon 300 g / L)
Diclofop-methyl
Difenacoum
Ethion
Fenamiphos
Iprodione
Furfural
Methidathion
Methiocarb
Monocrotophos
Terbufos
Thiodicarb
Zinc phosphide
Brodifacoum (liquid formulations -0.75 & 2.5 g/L)
Difethialone
Methamidophos
Benomyl
Methomyl 900 g/kg
Chlorfenvinphos
Carbaryl
Oxyfluorfen

II. Cancellation as of 31 December 2014 of all the products containing the active substances:

2,4-D dimethylamine
Paraquat
Endosulfan
Diuron

III. Products containing the active substances listed in N. 1 and 2 imported before theircancellation can continue to be used as long as they are within the validity period.

Maputo on July 15, 2014

The National Director

Dahomgd Rafikö

Reducing Risks of Highly Hazardous Pesticides in Mozambique

Step 1 – Shortlisting highly hazardous pesticides

Armando Marcos W. Come
Harold van der Valk

[final – 5 May 2014]

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With financial support from the SAICM Quick Start Programme

Acknowledgements

This study was conducted within the framework of Project EP/MOZ/101/UEP – *Reducing Risks of Highly Hazardous Pesticides in Mozambique*. The project is funded by the Quick Start Program of the Strategic Approach to International Chemicals Management (SAICM), the Food and Agriculture Organization of the United Nations and the Government of Mozambique.

The authors would like to gratefully acknowledge the information provided and the contributions made to this study by Ida Chongo and Marcelina Xavier (Ministry of Agriculture), Khalid Cassam and Francesca Mancini (FAO), Kimberly Nesci and Cathleen Barnes (US Environmental Protection Agency),

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1. Introduction

1.1 Project background

Pesticides are widely used in most areas of crop production in Mozambique to minimize infestations by pests and thus protect crops from potential yield losses and reduction of product quality. They are also widely applied for public health purposes, e.g. in malaria control.

The average annual volume of pesticide imports into Mozambique is approximately 1800 tonnes of formulated products (Figure 1). The import value of these pesticides is estimated, over the last three years, to be at least 495 million Meticais, or 16.6 million $US. An almost five-fold increase in pesticide imports has occurred in Mozambique since the 2003, well above world averages.

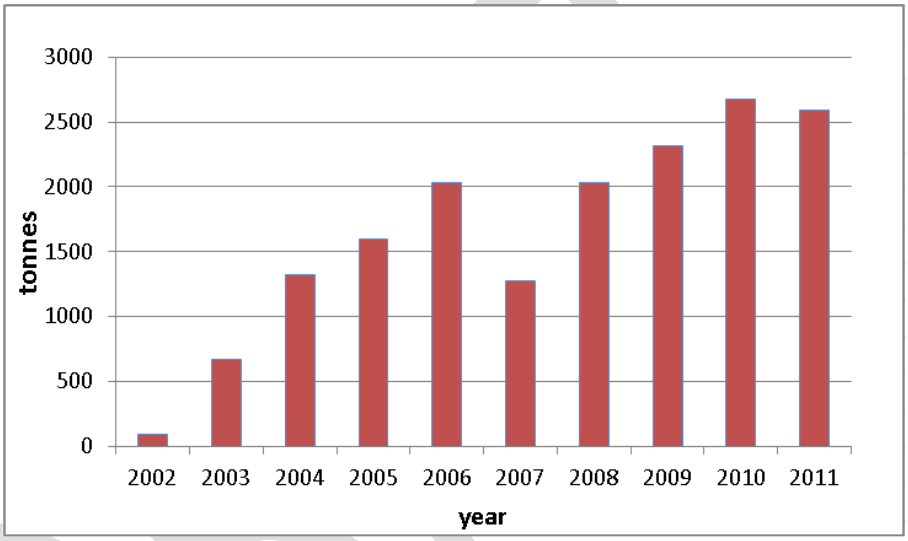

Figure 1. Annual imports of formulated pesticides into Mozambique between 2002 and 2011 (metric tons). Note that the data for 2002 are incomplete. (source: Lahr et al., 2014 based on Ministry of Agriculture statistics)

The large majority of pesticides, about 85%, are imported into Mozambique by private sector distributors and retailers, reflecting major change since the 1980s when pesticides were imported by a single state-run company. The remaining 15% of pesticides are imported directly by commercial farms, by commodity companies, and by various smaller importers. Direct pesticide imports by the state are now virtually non-existent, and state-funded imports are mainly limited to pesticides bought by the Ministry of Health for vector control and by INCAJU for cashew production.

A large part of pesticide distribution to end-users is conducted by private sector distributors and retailers, although exact figures are not available. Furthermore, private distributors deliver the pesticides they import to commodity companies which in turn will distribute the products to end-user farmers. This occurs mostly in cotton and to a smaller extent in tobacco. The private sector may also deliver pesticides to government structures who then distribute them to end-users. This is the case for INCAJU, which distributes pesticides to cashew farmers, and for the Ministry of Health, which distributes a part of the pesticides it orders to community groups to carry out mosquito control. In total, distribution by government structures represented less than 8% of the total pesticides imports.

Pesticide use may have benefits for different stakeholders, not only of farmers or consumers, but also of the society as a whole. At the same time, there is evidence of both direct and indirect risks involved in the use of these chemical substances both for humans and the environment. These risks will vary in importance (i.e. size, duration, extent, acceptability) depending on the type of pesticide and the specific use situation. Risk mitigation measures should be developed for all risks that are considered by the national regulatory authority to be unacceptable. However, given limited human and financial resources in many countries, and also in Mozambique, it may be more cost-effective to focus first on those pesticides and use situations that pose the highest risks and which are considered unacceptable by all relevant stakeholders.

Therefore, with the goal of reducing the greatest risks associated with pesticide use in Mozambique, a project entitled *Reducing Risks of Highly Hazardous Pesticides (HHPs) in Mozambique* was initiated by the Government of Mozambique, with the technical support of FAO's Pesticides Management Unit, and funded by SAICM Quick Start Programme Trust Fund. Its ultimate goal is to develop and implement an "HHP Risk Reduction Action Plan" in Mozambique for the most dangerous pesticides and use situations, resulting over time in the implementation of a variety of risk reduction measures based on a review of use conditions. These could include the cancellation of specific registrations of HHPs, implementation of risk mitigation measures, appropriate use restrictions, development of alternative pest management strategies, promotion of good agricultural practices, and possible phase-out of specific pesticides.

1.2 National and international policy framework

1.2.1 National framework

The major national legislative basis for pesticide distribution use in Mozambique is the Pesticide Management Regulation published under Decree 6/2009 of 31 March 2009 (RepMoz, 2009). The main objective of this Regulation, as laid out in its Article 2.1, is "*to ensure that all processes that involve working with or handling pesticides are executed without prejudice to public, animal and environmental health*". The Regulation further stipulates, in its Article 14, that pesticides will not be approved for use in Mozambique if, among others:

- the pesticide has unacceptable effects on organisms that are intended to be protected;
- the normal and recommended use of the pesticide has the potential to affect negatively human and/or animal health;
- the pesticide causes an unacceptable negative impact on the environment, particularly soil and water contamination, or affects organisms that are not targeted.

This clearly sets the boundaries within which the regulatory authorities in Mozambique can authorize a pesticide for use in the country.

In addition to the Pesticides Management Regulation, environmental, public health and labour legislation further defines the acceptability of risks of chemicals in general, and pesticides in particular, in Mozambique.

1.2.2 International framework

The International Code of Conduct on the Distribution and Use of Pesticides (FAO, 2002) describes the shared responsibility of many sectors of society to work together so that the

benefits to be derived from the necessary and acceptable use of pesticides are achieved without significant adverse effects on human health or the environment.

With respect to the availability and use of pesticides in a country, the Code stipulates in its Article 7, among others, that:

- Responsible authorities should give special attention to drafting rules and regulations on the availability of pesticides. These should be compatible with existing levels of user training and expertise. The parameters on which such decisions on availability are based vary widely and must be left to the discretion of each government.
- Two methods of restricting availability can be exercised by the responsible authority: not registering a product or, as a condition of registration, restricting the availability to certain groups of users in accordance with a national assessment of the hazards involved in the use of the product.
- Prohibition of the importation, sale and purchase of highly toxic and hazardous products, such as those included in WHO classes Ia and Ib, may be desirable if other control measures or good marketing practices are insufficient to ensure that the product can be handled with acceptable risk to the user.

For these reasons, pesticide risk reduction is one of the priority areas of FAO's pesticide management program.

At the request of the Committee on Agriculture (COAG), one of the governing bodies of FAO, the FAO/WHO Joint Meeting on Pesticide Management (JMPM) was asked in 2007 to provide guidance to FAO on the options to define highly hazardous pesticides (HHPs), beyond the definition provided in Article 7 of the Code, as well as on activities that could be initiated to reduce their risks. The JMPM defined on which basis HHPs could be identified (see Chapter 2.1 and FAO/WHO, 2008). The JMPM also recommended, as a general principle, that HHPs should not be registered for use unless:

i. governments establish a clear need;

ii. no alternatives, based on a risk–benefit analysis, are available; and

iii. control measures as well as good marketing practices are sufficient to ensure that the product can be handled with acceptable risk to human health and the environment.

In conjunction with these considerations, the Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam, 2009) demonstrates the commitment of FAO and UNEP to address challenges associate with highly hazardous and other pesticide use in Mozambique and other developing countries. Information available on banned or severely restricted pesticides under PIC helps strengthen national decision making on pesticides. The PIC procedure assists countries like Mozambique in avoiding imports of hazardous chemicals that they cannot manage safely under national conditions of use. As such, the Convention helps to prevent incidents before they occur, serving as an early warning system or first line of defence, internationally, that helps keep countries apprised of actions that are being taken by other countries in dealing with problematic chemicals.

These and other efforts, internationally, provide a framework for strengthened pesticide management actions on the ground, in countries such as Mozambique. And in return, as projects such as this one go forward, they contribute to achieving the overall objective of the Strategic Approach to International Chemicals Management (SAICM), which is the sound management of chemicals throughout their life cycle so that, by 2020, chemicals are used and produced in ways that lead to the minimization of significant adverse effects on human health and the environment.

1.3 The project

1.3.1 Objectives

The main objectives of the project are to:

- Identify pesticides and pesticide use situations which can be considered highly hazardous under Mozambican conditions.
- Elaborate a plan of action to reduce the risks posed by these highly hazardous pesticides.
- Initiate implementation of priority risk reduction activities.
- Review the results of priority risk reduction activities.
- Develop mid- and longer-term policies, programmes and projects to reduce the risk of highly hazardous pesticides.

1.3.2 Approach

The project is organized in five key steps, which are:

- **Step 1** will develop a database of pesticide products presently registered and legally imported to the country in the last 3 years, review Mozambique's registered pesticides against the JMPM criteria for HHPs, identify a list of HHPs being used within the country and development of survey methodology to be used in step 2.
- **Step 2** will conduct field surveys for the identified HHPs, to assess actual use and exposure under local conditions in Mozambique, as well as additional hazard and risk assessments as appropriate.

  On the basis of Steps 1 and 2, HHPs and cropping systems (or use situations) that require risk reduction measures will be identified.
- **Step 3** will develop Risk Reduction Action Plans, with the government and other relevant stakeholders, for HHPs and cropping systems or use situations where risks to human health and/or the environment are likely to be unacceptable.
- **Step 4** will focus on initial implementation of the Action Plans, with the national government, local communities, private/corporate sector, farmers, NGOs/CSOs, academia, scientific and technical community, and other relevant stakeholders carrying out a variety of risk activities both within the scope of this project, as well as in the longer term; and
- **Step 5** will review the Action Plan results achieved, make recommendations going forward, and evaluate the project.

This report specifically covers Step 1 of the project. Its main objective is to provide a short-list of HHPs on which to focus field surveys and hazard/risk assessments in Step 2.

The different activities in Steps 1 and 2 are outlined in Figure 2. They include:

i. Evaluation of all pesticides registered in Mozambique against the JMPM criteria.

ii. Elaboration of a list of HHPs and of pesticides "coming close" to HHPs (see Chapter 2 for more information).

iii. Evaluation of pesticide import statistics for Mozambique to assess which HHPs are presently being used in the country.

iv. Elaboration of a short-list of HHPs which will be further assessed through field surveys and hazard/risk assessments

The ultimate goal of Steps 1 and 2 is to define a list of HHPs, cropping systems and pesticide use situations which would require risk reduction, and for which Risk Reduction Action Plans will be developed under Step 3 of the project.

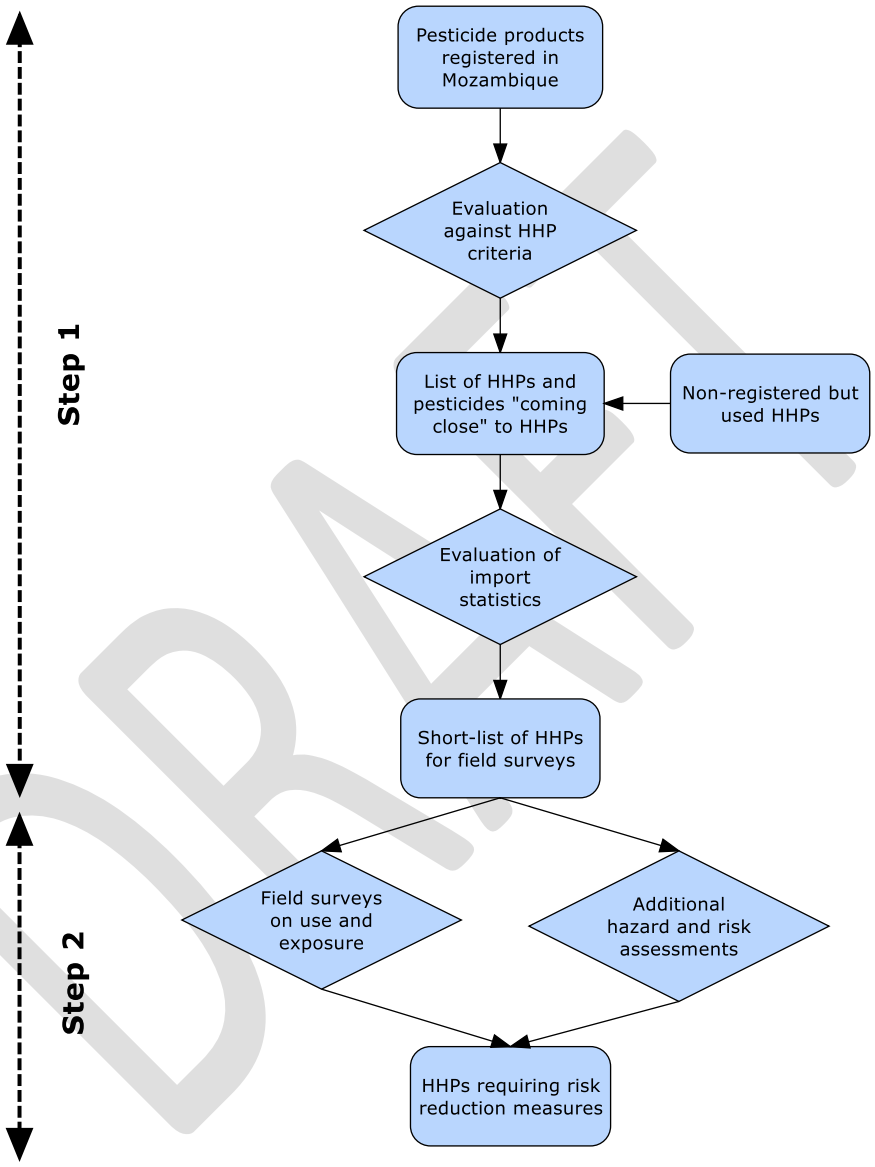

Figure 2. Schematic outline of the various activities in Steps 1 and 2 of the project. This report primarily covers Step 1.

2. Methodology

2.1 Criteria to define HHPs

The criteria that were used in this study to identify highly hazardous pesticides (HHPs) were those established by the FAO/WHO Joint Meeting on Pesticide Management (JMPM) (FAO/WHO, 2008). The JMPM recommended that HHPs should be defined as having one or more of the following characteristics:

- pesticide formulations that meet the criteria of classes Ia or Ib of the *WHO Recommended Classification of Pesticides by Hazard*;

  or

- pesticide active ingredients and their formulations that meet the criteria of carcinogenicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

  or

- pesticide active ingredients and their formulations that meet the criteria of mutagenicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

  or

- pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

  or

- pesticide active ingredients listed by the *Stockholm Convention* in its Annexes A and B, and those meeting all the criteria in paragraph 1 of annex D of the Convention;

  or

- pesticide active ingredients and formulations listed by the *Rotterdam Convention* in its Annex III;

  or

- pesticides listed under the *Montreal Protocol*;

  or

- pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

The JMPM criteria above were used to establish a list of HHPs registered in Mozambique.

Added to this list were:

- Pesticides that are not registered in Mozambique anymore, but for which limited (left-over) quantities are still used in the country.
- Pesticides with characteristics which "come close" to the HHP criteria. A number of pesticides did not meet the WHO class criteria defined by the JMPM, but their acute or chronic toxicity "comes close" to the criteria limits, or they have been marked in the WHO classification as of particular concern with respect to their toxicity.

The following criteria were applied to identify such pesticides "coming close" to HHPs:

- For liquid formulations: pesticide products with an acute oral LD_{50}< 200 mg/kg or an acute dermal LD_{50}< 400 mg/kg (note that these are the Class Ib limits in the previous version of the WHO Classification (WHO, 2005)).
- For solid formulations: pesticide products with an acute oral LD_{50}< 100 mg/kg or an acute dermal LD_{50}< 200 mg/kg.
- Pesticides marked in the WHO classification as of particular concern with respect to chronic toxicity other than the CMR-criteria (*carcinogenicity-mutagenicity-reproductive toxicity*) listed in sections 2.2.4 to 2.2.6 below.
- Pesticides for which carcinogenicity evaluations by different registration/assessment authorities did not lead to consistent classification as GHS Category 1A or 1B, but which were, based on the evidence of one of these authorities, considered of particular concern for use in Mozambique.

2.2 Data collection

2.2.1 Introduction

In principle, the pesticide registration dossier should contain the information that is required for a responsible authority to identify whether a pesticide may be considered an HHP. However, in many developing countries, registration dossiers do not contain sufficient information for such an evaluation. And even if the information is provided in the dossier, the registration authority will often not have the technical capacity to assess the accuracy of the information or to evaluate submitted studies against all the JMPM criteria.

No international or national databases exist which list highly hazardous pesticides (HHPs) based on all the criteria listed by the JMPM. However, various databases are available for individual criteria. These include international databases, e.g. for the criteria linked to the Rotterdam and Stockholm Conventions, or for the *WHO Classification of pesticides by hazard*; others are national or regional, such as the classification and labelling of chemicals databases of the European Union.

In this study, registration dossiers submitted to the registration authority of Mozambique were used to assess pesticides against some of the HHP criteria. International databases or assessments, as well as national or regional databases of various reputable pesticide registration authorities, we accessed to review pesticides against other HHP criteria. The exact procedures for each of the HHP criteria are further described in the chapters below.

2.2.2 Starting data set

The initial dataset used for this study was the list of pesticides registered for use in Mozambique in June 2012, as provided by the Ministry of Agriculture of Mozambique (Minag, 2012). At that date, 646 formulated pesticide products were registered in the country

The 646 registered products contained 192 active substances, of which six were synergists or other additives, and nine others were microbial pesticides.

2.2.3 WHO hazard class

HHPs

The JMPM considers as HHP all *"Pesticide formulations that meet the criteria of classes Ia or Ib of the WHO Recommended Classification of Pesticides by Hazard"*. The latest version of the WHO Classification (WHO, 2010) is shown in Table 1.

Table 1. WHO classification of pesticides by hazard (WHO, 2010)

WHO Class		LD_{50} for the rat *(mg/kg body weight)*	
		Oral	Dermal
Ia	Extremely hazardous	< 5	< 50
Ib	Highly hazardous	5–50	50–200
II	Moderately hazardous	50–2000	200–2000
III	Slightly hazardous	> 2000	> 2000
U	Unlikely to present acute hazard	≥5000	

To evaluate this criterion, all pesticide formulations registered in Mozambique were classified against the WHO Classification. The oral and dermal LD_{50} value of the formulation, as provided in the registration dossier, was used as the basis for the classification.

In addition, for all formulations a theoretical LD_{50} was calculated, based on the LD_{50} value of the active ingredient(s) and its concentration(s) in the formulated product. LD_{50} values for the active ingredient were obtained from the WHO Classification or, if not listed, from the FootPrint Pesticides Properties Database (PPDB, 2012). This theoretical LD_{50} of the formulation was used in case there were no values in the registration dossier, or to check whether the LD_{50} values provided in the dossier appeared reasonable given the active ingredient content. LD_{50} values from the registration dossier which deviated greatly from the theoretical values were omitted from the analysis.

Whenever there were more products registered for the same active ingredient and concentration, and different LD_{50} values were reported for these pesticide formulations, the lowest LD_{50} value was used for final classification. If oral and dermal LD_{50} values resulted in different classifications, the more hazardous classification was retained for the pesticide product.

2.2.4 GHS carcinogenic hazard

The JMPM considers as HHP all *"Pesticide active ingredients and their formulations that meet the criteria of carcinogenicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals (GHS)"*.

The carcinogenicity categories 1A and 1B are defined as by the GHS(2011) as shown in Table 2.

Table 2. Hazard categories for carcinogens, according to the GHS. See GHS (2011) for further details.

Category	Description
1	Known or presumed human carcinogen.
1A	Known to have carcinogenic potential for humans; the placing of a substance is large based on human evidence.
1B	Presumed to have carcinogenic potential for humans; the placing of a substance is largely based on animal evidence.
2	Suspected human carcinogen.

The GHS itself does not provide lists of pesticides and their classifications. Therefore, the following data sources were used to check whether a pesticide would meet GHS Class 1A or 1B for carcinogenicity:

i. The ***WHO Classification of Pesticides by Hazard*** (WHO, 2010)

The footnotes to the various tables were checked for references to carcinogenicity. If a pesticide was listed as carcinogenic in the WHO Classification, it was considered, for this assessment, to meet GHS carcinogenicity Category 1A or 1B.

ii. The ***IARC Monographs on the evaluation of carcinogenic risks to humans*** (IARC, 2012).

Pesticides classified as IARC Group 1 (*carcinogenic to humans*) and Group 2A (*probably carcinogenic to humans*) were considered, for this assessment, to meet GHS carcinogenicity Category 1A or 1B.

iii. The ***European Union Pesticides Database*** (EU, 2012)

This database provides information on plant protection products, but not on other pesticides (biocides). EU hazard classifications follow the GHS. Therefore, pesticides listed in this database as "*carc. 1A*" are GHS Category 1A, and those listed as "*carc. 1B*" are GHS Category 1B.

iv. The ***European Chemical Substances Information System (ESIS)***– *Database of Harmonized Classification and Labelling Elements (CLP/GHS)* (ESIS, 2012)

In addition to plant protection products, this database provides hazard classification informationon biocides. EU hazard classifications follow the GHS. Therefore, pesticides listed in this database as "*carc. 1A*" are GHS Category 1A, and those listed as "*carc. 1B*" are GHS Category 1B.

v. The US EPA evaluations of carcinogenic potential, as provided in the ***Integrated Risk Information System (IRIS)*** (IRIS, 2012).

For this assessment, the following correlations were assumed between the various EPA carcinogenicity classifications and the GHS carcinogenicity categories:

- 1986 guidelines: *"EPA class A (human carcinogen)"* were assumed to be GHS Category 1A, and *"EPA class B1 or B2 (probable human carcinogen)"*to be GHS Category 1B.
- 1996 guidelines: "*EPA known/likely carcinogen"* was assumed to be GHS Category 1A or 1B.

– 1999 guidelines: "*EPA carcinogenic"* was assumed to be GHS Category 1A and *EPA "likely carcinogenic* " was assumed to be GHS Category 1B.

– 2005 guidelines: *"EPA carcinogenic"* was assumed for this assessment to be GHS Category 1A and *"EPA likely carcinogenic"* was assumed to be GHS Category 1B.

vi. The list of **Chemicals Evaluated for Carcinogenic Potential,** compiled by the Office of Pesticide Programs of the US EPA (US-EPA, 2012a).

The same correlations were assumed as listed above (section v.) between the various EPA carcinogenicity classifications and the GHS carcinogenicity categories.

If pesticides were not covered by one or more of the previous sources, the data reviews mentioned below were verified:

vii. Pesticides evaluated by the FAO/WHO ***Joint Meeting on Pesticide Residues*** (JMPR, 2012).

The JMPR toxicology reviews were accessed for selected pesticides to check whether the pesticide is considered to be carcinogenic. Since no standardised carcinogenicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

viii. US EPA ***Pesticide Chemical Search*** (US-EPA, 2012b)

This database was accessed to obtain reviews for selected pesticides, generally *Pesticide Fact Sheets* or *Re-registration Eligibility Documents* (REDs). Since no standardised carcinogenicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

ix. WHO ***Specifications for pesticides used in public health*** (WHO, 2012)

For a limited number of pesticides, the *WHO Specifications for pesticides used in public health*(new procedure) were accessed. Since no standardised carcinogenicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

In principle, if one of these data sources classified a pesticide as (equivalent to) GHS Categories 1À or 1B, the pesticide was considered a HHP. Only if the positive classification appeared outdated, and more recent comprehensive reviews or classifications were available showing that the pesticide was not carcinogenic, the pesticide was not considered a HHP based on this criterion.

2.2.5 GHS mutagenic hazard

The JMPM considers as HHP all *"Pesticide active ingredients and their formulations that meet the criteria of mutagenicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals (GHS)"*

The mutagenicity categories 1A and 1B are defined as by the GHS (2011) as shown in Table 3.

Table 3. Hazard categories for mutagens, according to the GHS. See GHS (2011) for further details.

Category	Description
1	Substances known to induce heritable mutations or to be regarded as if they induce heritable mutations in the germ cells of humans.
1A	Substances known to induce heritable mutations in germ cells of humans.
1B	Substances which should be regarded as if they induce heritable mutations in the germ cells of humans.
2	Substances which cause concern for humans owing to the possibility that they may induce heritable mutations in the germ cells of humans.

The GHS itself does not provide lists of pesticides and their classifications. Therefore, the following data sources were used to check whether a pesticide would meet GHS Class 1A or 1B for germ cell mutagenicity.

i. The ***WHO Classification of Pesticides by Hazard*** (WHO, 2010)

The footnotes to the various tables were checked for references to mutagenicity. If a pesticide was listed as mutagenic in the WHO Classification, it was considered, for this assessment, to meet GHS mutagenicity Category 1A or 1B.

ii. The ***European Union Pesticides Database*** (EU, 2012)

This database provides information on plant protection products, but not on other pesticides (biocides). EU hazard classifications follow the GHS. Therefore, pesticides listed in this database as "*muta. 1A*" are GHS Category 1A, and those listed as "*muta. 1B*" are GHS Category 1B.

iii. The ***European Chemical Substances Information System (ESIS)*** – *Database of Harmonized Classification and Labelling Elements (CLP/GHS)* (ESIS, 2012)

In addition to plant protection products, this database provides hazard classification information on biocides. EU hazard classifications follow the GHS. Therefore, pesticides listed in this database as "*muta. 1A*" are GHS Category 1A, and those listed as "*muta. 1B*" are GHS Category 1B.

If pesticides were not covered by one or more of the previous sources, the data reviews mentioned below were verified:

iv. Pesticides evaluated by the FAO/WHO ***Joint Meeting on Pesticide Residues*** (JMPR, 2012).

The JMPR toxicology reviews were accessed for selected pesticides to check whether the pesticide is considered to be germ cell mutagens. Since no standardised mutagenicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

v. US EPA ***Pesticide Chemical Search*** (US-EPA, 2012b)

This database was accessed to obtain reviews for selected pesticides, generally *Pesticide Fact Sheets* or *Re-registration Eligibility Documents* (REDs). Since no standardised mutagenicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

vi.. WHO ***Specifications for pesticides used in public health*** (WHO, 2012)

For a limited number of pesticides, the *WHO Specifications for pesticides used in public health*(new procedure) were accessed. Since no standardised mutagenicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

In principle, if one of these data sources classified a pesticide as (equivalent to) GHS Categories 1À or 1B, the pesticide was considered a HHP. Only if the positive classification appeared outdated, and more recent comprehensive reviews or classifications were available showing that the pesticide was not a germ cell mutagen, the pesticide was not considered a HHP based on this criterion.

2.2.6 GHS reproductive toxicity hazard

The JMPM considers as HHP all *"Pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of the Globally Harmonized System on Classification and Labelling of Chemicals (GHS)"*

The reproductive toxicity categories 1A and 1B are defined as by the GHS (2011) as shown in Table 4.

Table 4. Hazard categories for reproductive toxicants, according to the GHS. See GHS (2011) for further details.

Category	Description
1	Known or presumed human reproductive toxicant
1A	Known human reproductive toxicant
1B	Presumed human reproductive toxicant
2	Suspected human reproductive toxicant

The GHS itself does not provide lists of pesticides and their classifications. Therefore, the following data sources were used to check whether a pesticide would meet GHS Class 1A or 1B for reproductive toxicity.

i. The ***WHO Classification of Pesticides by Hazard*** (WHO, 2010)

The footnotes to the various tables were checked for references to reproductive toxicity. If a pesticide was listed as a reproductive toxicant in the WHO Classification, it was considered, for this assessment, to meet GHS reproductive toxicity Category 1A or 1B.

ii. The ***European Union Pesticides Database*** (EU, 2012)

This database provides information on plant protection products, but not on other pesticides (biocides). EU hazard classifications follow the GHS. Therefore, pesticides listed in this database as "*repro. 1A*" are GHS Category 1A, and those listed as "*repro. 1B*" are GHS Category 1B.

iii. The ***European Chemical Substances Information System (ESIS)*** – *Database of Harmonized Classification and Labelling Elements (CLP/GHS)* (ESIS, 2012)

In addition to plant protection products, this database provides hazard classification information on biocides. EU hazard classifications follow the GHS. Therefore, pesticides listed in this database as "*repro. 1A*" are GHS Category 1A, and those listed as "*repro. 1B*" are GHS Category 1B.

If pesticides were not covered by one or more of the previous sources, the data reviews mentioned below were verified:

iv. Pesticides evaluated by the FAO/WHO ***Joint Meeting on Pesticide Residues*** (JMPR, 2012).

The JMPR toxicology reviews were accessed for selected pesticides to check whether the pesticide is considered to be a reproductive toxicant. Since no standardised reproduction toxicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

v. US EPA ***Pesticide Chemical Search*** (US-EPA, 2012b)

This database was accessed to obtain reviews for selected pesticides, generally *Pesticide Fact Sheets* or *Re-registration Eligibility Documents* (REDs). Since no standardised reproduction toxicity classification is used in these reviews, pesticides were assessed on a case-by-case basis.

vi. WHO ***Specifications for pesticides used in public health*** (WHO, 2012)
For a limited number of pesticides, the *WHO Specifications for pesticides used in public health* (new procedure) were accessed. Since no standardised classification for reproductive toxicants is used in these reviews, pesticides were assessed on a case-by-case basis.

In principle, if one of these data sources classified a pesticide as (equivalent to) GHS Categories 1À or 1B, the pesticide was considered a HHP. Only if the positive classification appeared outdated, and more recent comprehensive reviews or classifications were available showing that the pesticide was not a reproductive toxicant, the pesticide was not considered a HHP based on this criterion.

2.2.7 Stockholm Convention

The JMPM considers as HHP all *"Pesticide active ingredients listed by the Stockholm Convention in its Annexes A and B, and those meeting all the criteria in paragraph 1 of Annex D of the Convention"*

Pesticides listed in Annex A and B were obtained directly from the Convention web site (Stockholm, 2012).

Annex D of the Stockholm Convention lists the screening criteria for inclusion of a pesticide in Annex A, B and/or C of the Convention (Stockholm, 2009). With respect to Annex D, the Stockholm Convention stipulates in its Article 3, that :

> **3.** *Each Party that has one or more regulatory and assessment schemes for new pesticides or new industrial chemicals shall take measures to regulate with the aim of preventing the production and use of new pesticides or new industrial chemicals which, taking into consideration the criteria in paragraph 1 of Annex D, exhibit the characteristics of persistent organic pollutants.*
>
> **4.** *Each Party that has one or more regulatory and assessment schemes for pesticides or industrial chemicals shall, where appropriate, take into consideration within these schemes the criteria in paragraph 1 of Annex D when conducting assessments of pesticides or industrial chemicals currently in use.*

Therefore, and in particular to meet Article 3.4 above, all pesticides registered in Mozambique were reviewed against the criteria listed in Annex D. The screening criteria that identify a POP, as defined in paragraph1 of Annex D are listed in Table 5.

For each of the registered pesticides, the data were compiled using the FootPrint Pesticide Properties Database (PPDB, 2012), as follows:

Persistence

- Half-life (DT_{50}) in water: aqueous photolysis DT_{50}; aqueous hydrolysis DT_{50}, and water phase only DT_{50} of the water-sediment study. The latter parameter, or any listed field data, had preference in the assessment of persistence in water. The range of relevant values was noted in the evaluation spreadsheet.
- Half-life (DT_{50}) in soil: DT_{50} (typical), DT_{50} (lab), DT_{50} (field), any DT_{50} values (lab or field) given in the "note" to this section in FootPrint. Any listed field data had preference in the assessment of persistence in soil. The range of relevant values was noted in the evaluation spreadsheet.
- Half-life (DT_{50}) in sediment: Water-Sediment DT_{50}

Table 5. Screening criteria to identify a Persistent Organic Pollutant (POP) according to the Stockholm Convention (Annex D) (Stockholm, 2009)

Characteristic	Criteria	
b. Persistence	(i)	Evidence that the half-life of the chemical in water is greater than two months, or that its half-life in soil is greater than six months, or that its half-life in sediment is greater than six months; or
	(ii)	Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of this Convention;
c. Bio-accumulation	(i)	Evidence that the bio-concentration factor or bio-accumulation factor in aquatic species for the chemical is greater than 5,000 or, in the absence of such data, that the log K_{ow} is greater than 5;
	(ii)	Evidence that a chemical presents other reasons for concern, such as high bio-accumulation in other species, high toxicity or ecotoxicity; or
	(iii)	Monitoring data in biota indicating that the bio-accumulation potential of the chemical is sufficient to justify its consideration within the scope of this Convention;
d. Potential for long-range environmental transport	(i)	Measured levels of the chemical in locations distant from the sources of its release that are of potential concern;
	(ii)	Monitoring data showing that long-range environmental transport of the chemical, with the potential for transfer to a receiving environment, may have occurred via air, water or migratory species; or
	(iii)	Environmental fate properties and/or model results that demonstrate that the chemical has a potential for long-range environmental transport through air, water or migratory species, with the potential for transfer to a receiving environment in locations distant from the sources of its release. For a chemical that migrates significantly through the air, its half-life in air should be greater than two days; and
e. Adverse effects	(i)	Evidence of adverse effects to human health or to the environment that justifies consideration of the chemical within the scope of this Convention; or
	(ii)	Toxicity or ecotoxicity data that indicate the potential for damage to human health or to the environment.

Bioaccumulation

- Octanol–water partition coefficient – log K_{ow} (= log P in FootPrint).
- Bioconcentration factor in aquatic species (BCF).
- Bioacummulation factor in aquatic species (BAF) (if listed).
- Bioacummulation factor in other species (BAF) (if listed).

Potential for long-range transport

- This characteristic was not assessed, as it was not considered relevant for the identification of HHPs in Mozambique itself.

Adverse effects

- This characteristic was only assessed for pesticides which were both persistent and bioaccumulative according to the criteria listed above. For this study, such pesticides were considered HHPs if they fell in WHO hazard class II or higher.
- No other toxicity or ecotoxicity assessments were conducted to assess whether there was "potential for damage to human health or to the environment".

2.2.8 Rotterdam Convention

The JMPM considers as HHP all *"Pesticide active ingredients and formulations listed by the Rotterdam Convention in its Annex III"*.

Pesticides listed in Annex III were obtained directly from the Convention web site (Rotterdam, 2012)

2.2.9 Montreal Protocol

The JMPM considers as HHP all *"Pesticides listed under the Montreal Protocol"*.

The only pesticide presently listed under the Montreal Protocol is methyl bromide (Montreal, 2012)

2.2.10 High incidence of severe or irreversible adverse effects

The JMPM considers as HHP all *"Pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment"*.

This parameter was not assessed in Step 1 of the project, as it requires information from actual use in Mozambique, or from similar use situations. Pesticide use surveys have been programmed for Step 2 of the project, however.

2.2.11 Import statistics

Import statistics were obtained from the Pesticide Registration Section of the Ministry of Agriculture. Mozambique applies an import permit system and all official pesticide imports are registration by the Ministry of Agriculture. While such a system does not allow for records of illegal imports, the import register in Mozambique is generally considered to represent a large fraction of pesticides entering the country. No local pesticide manufacturing or formulation takes place in Mozambique.

For this study, the import statistics of 2010, 2011 and the first half of 2012 were reviewed. Total quantities imported during that period for all products with the same active ingredient(s) were considered a proxy for the present use of that active ingredient in the country. Implicitly, it was assumed that pesticides imported before 2010 would have been used up by the time of the study and not be used anymore.

2.3 Data compilation

All assessments made and data compiled as described in the sections above were compiled in a spreadsheet. This was done to allow full transparency with respect to the identification process of the HHPs, but also to allow updating of the list of HHPs would new information become available. The latest version of the spreadsheet is available on request. This version does not contain the detailed import statistics, however, as these are considered confidential.

3. Results

3.1 Data availability

Using the data sources laid out in Chapter 2, it was possible to review all HHP criteria defined by the JMPM for most of the pesticides registered in Mozambique, except for the last criterion, which refers to pesticides that have shown a high incidence of severe or irreversible adverse effects – see Section 2.2.10).

Acute toxicity

LD_{50} values for the pesticide formulations were provided in the registration dossier for 97% (oral LD_{50}) and 93% (dermal LD_{50}) of the registered products. However, in some cases the LD_{50} values of the formulation appeared erroneous when compare to the theoretical values calculated on the basis of the a.i.; in others, the LD_{50} of the formulation provided by the registrar was identical to the a.i. In total, 12% of the oral LD_{50} values for the formulations were either not reported in the dossier or were considered erroneous; this was the case for 10% of the dermal LD_{50} values. However, in many cases, LD_{50} values of the formulation could be estimated based on the LD_{50} values of the a.i.

As a result, LD_{50} values for the formulation were available or could be estimated for all registered pesticide products except for three microbial pesticides and one citronella oil (i.e. > 99% of the total).

Overall, data availability for acute toxicity, which is at the basis of the WHO Class criterion of the JMPM, can be considered satisfactory.

Carcinogenicity, mutagenicity, reproductive toxicity (CMR)

Evaluations on carcinogenic potential were available for 93% of the active ingredients registered in Mozambique, representing 96% of the number of registered formulated products. Of the 11 a.i.'s lacking carcinogenicity evaluations, four were adjuvants/synergists, one a repellent, one a microbial pesticide and one a pheromone; the remaining four were "regular" chemical pesticides.

Evaluations on germ cell mutagenicity were available for 90% of the active ingredients registered in Mozambique, representing 95% of the number of registered formulated products. Of the 20 a.i.'s lacking carcinogenicity evaluations, four were adjuvants/synergists, three repellents, one a microbial pesticide and one a pheromone; the remaining 11 were "regular" chemical pesticides.

Evaluations on reproductive toxicity were available also for 90% of the active ingredients registered in Mozambique, representing 94% of the number of registered formulated products. Of the 20 a.i.'s lacking reproductive toxicity evaluations, four were adjuvants/synergists, two repellents, one a microbial pesticide and one a pheromone; the remaining 12 were "regular" chemical pesticides.

Overall, data to evaluate the CMR criteria of the JMPM were available for >90% of the a.i. and >94% of registered formulations. Eight to twelve active ingredients of "regular" chemical pesticide a.i.'s had not been evaluated and/or classified for CMR criteria by any of the used sources. It can certainly not be excluded that evaluation of other data sources would result in proper classification of these a.i.'s, but that was not further attempted in this study.

Rotterdam and Stockholm Conventions, and Montreal Protocol

Inclusion in the lists of regulated chemicals of these three international instruments was obviously complete and did not show any data gaps.

On the other hand, there were data gaps in the parameters needed to classify a pesticide as a POP according to Annex D of the Stockholm Convention. Only one data source was used to obtain this information, the FootPrint Pesticide Properties Database. However, since the FootPrint database compiles its data from various reputable reviews and databases, it is generally considered to be rather complete.

In spite of the extensiveness of the FootPrint database, for 36 a.i.'s (19% of the total) half-lives in water were not available. In many cases this absence was understandable (e.g. for microbial pesticides, repellents, pheromones), but for 17 a.i.'s of "regular" chemical pesticides registered in Mozambique, this information was not present either.

Half-lives in soil were available for more pesticides in the FootPrint database. Data were lacking for 27 a.i.'s (15% of the total), of which eight were "regular" chemical pesticides registered in Mozambique.

In contrast, half-life data for sediments (water-sediment studies) were not available for 42% of the a.i.'s. This included 58 "regular" chemical pesticide a.i.'s for which data were lacking. This is not entirely surprising, as water-sediment studies are fairly recent requirements in pesticide registration in Europe and the U.S.

Bioaccumulation potential is assessed using the bioconcentration factor (BCF) for aquatic organisms, or the bioaccumulation factor (BAF) for aquatic or terrestrial organisms. BAFs were not available in FootPrint for any of the registered a.i.'s. BCFs were not available for 76 a.i.'s (40% of the total).

In the absence of BCFs, the octanol-water partition coefficient (K_{ow} or P) of the pesticide is used to evaluate bioaccumulation potential. K_{ow}-values were available for most pesticides, with data absent for only 21 a.i.'s (10% of the total), most of which were microbial pesticides, synergists or adjuvants, and pheromones.

Based on the above, it may be concluded that for the majority of pesticides registered in Mozambique it was possible to assess whether a pesticide is persistent or bioaccumulative according to the Stockholm Convention, but that there were still considerable data gaps.

3.2 Identification of HHPs

Taking into account the limitations due to data gaps described above, in total 57 registered pesticide formulations, containing 24 active ingredients, were identified as HHPs. In addition, two pesticides were also listed as HHP: DDT and methyl-bromide (Figure 3). The latter two pesticides are not registered in Mozambique anymore, but remaining stocks are still being used (for DDT) or their use is still temporarily being allowed (for methyl bromide). Further details for all identified HHPs are provided in Table 6.

The majority of HHPs were identified on the basis of their acute toxicity. Thirty-seven out of 59 formulated products were WHO class Ia or Ib (based on acute toxicity; not on chronic), or highly toxic by inhalation (Figure 4).

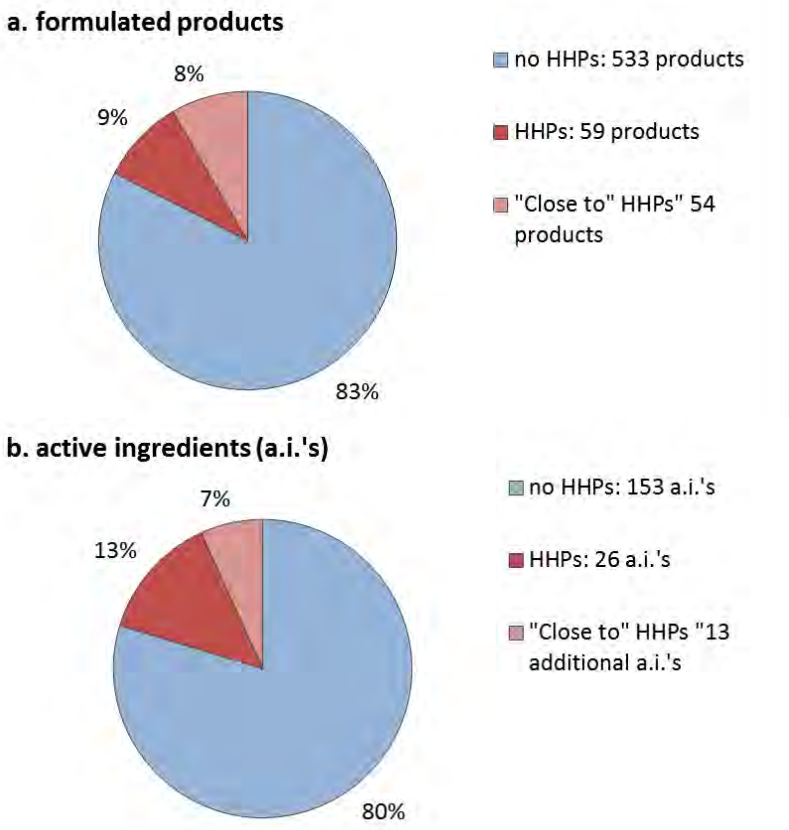

Figure 3. The number and percentage of identified highly hazardous pesticides (HHPs), pesticides "close to HHPs" in Mozambique. a. formulated products (total = 646), and b. active ingredients (a.i.'s) (total = 192).

The second most important criterion was listing in Annex III of the Rotterdam Convention (Figure 4). This was the case for 17 out of 59 formulated products, or 6 out of 26 active ingredients identified as HHP.

Two active ingredients, representing 5 pesticide products, were listed in Annex A or B of the Stockholm Convention. Three other pesticide active ingredients were both persistent and bioaccumulative according to Annex D criteria (diafenthiuron, difenacoum and difethialone), but only diafenthiuron is moderately toxic to humans. Furthermore, the insecticide diafenthiuron is considered hazardous to aquatic organisms while difenacoum and difethialone, both rodenticides, are considered hazardous to aquatic organisms as well as to birds and mammals. While this does not mean that these organisms will be unacceptably affected when the pesticides are applied, the "potential for damage to the environment" exists (as indicated in Annex D of the Stockholm Convention), and these pesticides were therefore identified as HHPs in Table 6.

One pesticide was listed under the Montreal Protocol.

Two active ingredients were classified as GHS Category 1A & 1B carcinogen, three a.i.'s as mutagen and three a.i.'s as reproductive toxicant. For 14 active ingredients, carcinogenicity evaluations by the EU and the US-EPA did not lead to the same conclusion with respect to classification; these were further evaluated under Section 3.3.

In total, seven active ingredients met more than one JMPM HHP criterion (Table 6).

Table 6. Highly hazardous pesticides (HHPs) identified among the pesticide products registered in Mozambique, and pesticide products "coming close" to being considered HHPs. For the selection criteria and the applied methodology see Chapter 2 of this report.

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
Pesticides meeting the HHP criteria							
455	Controler 48% SE	Alachlor 336 g/l (+ Atrazine 144 g/l)	Rott. Annex III	Maize, sunflower, soybean, groundnut, vegetables	0		EU: No (H[2]& E[3]) USA: Yes
666	Volcano alachlor 48% EC	Alachlor 480 g/l	Rott. Annex III				
509	Seter 48% EC	Alachlor 480 g/l	Rott. Annex III				
644	Volcano Aldicarb 15% GR	Aldicarb 150 g/kg	WHO Ib; Rott. Annex III	Citrus (nurseries)	0		EU: No (E) USA: Yes, but being phased out (H & E)
1172	Fumate 56% FT	Aluminium Phosphide 560 g/kg	Highly toxic by inhalation	Storage insect pests of: tobacco, cereals, groundnut, oilseeds	29844 kg (2010) 14690 kg (2011) 1311 kg (2012) 705 (2013)		EU: Yes USA: Yes
1054	Moz Aluminium Phosphide Pellets	Aluminium Phosphide 560 g/kg	Highly toxic by inhalation				
581	Phosgard 56% FT	Aluminium phosphide 560 g/kg	Highly toxic by inhalation				
773	Falfume 57% FT	Aluminium Phosphide 570 g/kg	Highly toxic by inhalation				
1071	Moz Aluminium Phosphide Tablets	Aluminium Phosphide 570 g/kg	Highly toxic by inhalation				
1129	Quickphos 57% FT	Aluminium Phosphide 570 g/kg	Highly toxic by inhalation				
1080	Biophos 57% FW	Aluminium phosphide 570 g/kg	Highly toxic by inhalation				
1028	Celphos 57% FT	Aluminium phosphide 570 g/kg	Highly toxic by inhalation				
664	Volcano Aluminium Phosphide 57% FT	Aluminium phosphide 570 g/kg	Highly toxic by inhalation				
467	Benopec 50% WP	Benomyl 500 g/kg	Mutagen; reproductive toxicant	Apple, pineapple	5600 kg (2010)		EU: No (H & E) USA: No; voluntary

[1] EU (2012) and US-EPA (2012b), checked on 26 October 2012

[2] H = not registered due to unacceptable risk to human health

[3] E = not registered due to unacceptable risk to the environment

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
772	Volcano Demeter 50% WP	Benomyl 500 g/kg	Mutagen; reproductive toxicant		2000 kg (2012)		cancellation (H)
793	Supa-Kill Líquid Rat and Mouse Bait	Brodifacoum 0,75 g/L	WHO class Ib	Rodents	40 L (2011) 28 L (2012)	Also formulation with lower concentration registered	EU: No (NS[4]) USA:Yes
952	Brokir 0,075% CB	Brodifacoum 0,75 g/L	WHO class Ib				
837	Rodex Profissional Líquid Concentrate	Brodifacoum 2,5 g/kg	WHO class Ib				
681	Duett 25% SC	Carbendazim 125 g/l (+ Epoxiconazole 125 g/l)	Mutagen; reproductive toxicant	Cereals, groundnut	5 L (2011)		EU: Yes USA:Yes
126	Curaterr 10% GR	Carbofuran 100 g/kg	WHO class Ib	Maize, sugarcane	0		EU: No (H & E) USA:No; cancellation in progress (H & E)
504	Carbofurão 5% GR	Carbofuran 50 g/kg	WHO class Ib				
254	Polo 50% SC	Diafenthiuron 500 g/l	Stockh. Annex D (persistent, bioaccumulative and potential for damage to the humans or the environment)	Beans, cucumber, pepper, tomato, potato	0		EU: No (NS) USA: No
1202	Divos 100% EC	Dichlorvos 1000 g/l	WHO class Ib	Flowers, vegetables, stored cereals, domestic uses, veterinary uses	448 L (2010) 3000 L (2011) 2400 L (2012) 2584 (2013)		EU: No (H) USA:Yes
984	Nuvan 100% EC	Dichlorvos 1000 g/l	WHO class Ib				
774	Falcovos 100% EC	Dichlorvos 1000 g/l	WHO class Ib				
984	Nuvam 100% EC	Dichlorvos 1000 g/l	WHO class Ib				
1220	Diclofop–methyl 37,8% EC	Diclofop–methyl 378 g/l	carcinogen	Wheat, barley, triticale, peas	0		EU: Yes USA:Yes
1055	Moz Tornado 0,01% BB	Difenacoum 0,1 g/kg	Stockh. Annex D (persistent, bioaccumulative and potential for damage to the environment)	Rodents	48 (2013)		EU: Yes USA: Yes

[4] NS = not registered because no (complete) dossier was submitted

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
944	Finale Rat And Mouse Grain Bait	Difethialone 0,025 g/kg	Stockh. Annex D (persistent, bioaccumulative and potential for damage to the environment)	Rodents	0		EU: No (NS) USA: Yes
969	Finale Rat And Mouse Pellets	Difethialone 0,025 g/kg	Stockh. Annex D (persistent, bioaccumulative and potential for damage to the environment)				
943	Finale Rat And Mouse Wax Bait	Difethialone 0,025 g/kg	Stockh. Annex D (persistent, bioaccumulative and potential for damage to the environment)				
719	Ratex Pellts	Difethialone 0,025 g/kg	Stockh. Annex D (persistent, bioaccumulative and potential for damage to the environment)				
1027	Endocel 35% EC	Endosulfan 350 g/l	Stockh. Annex A; Rott. Annex III	Cotton, cocoa, cereals, vegetables, flowers,	2585 L (2010) 7280 L (2011) 9150 L (2012)		EU: No (H & E) USA:Yes,but phase out in progress
447	Endopec 35% EC	Endosulfan 350 g/l	Stockh. Annex A; Rott. Annex III				
825	Enticer 35% EC	Endosulfan 350 g/l	Stockh. Annex A; Rott. Annex III				
605	Volcano Endosulfão 35% EC	Endosulfan 350 g/l	Stockh. Annex A; Rott. Annex III				
518	Eticide 101% EC	Ethion 1010 g/l	WHO class Ib	Veterinary use	0		EU: No (NS) USA:No; voluntary cancellation (H)
483	Nemacur 40% EC	Fenamiphos 400 g/l	WHO class Ib	Tobacco, citrus, vegetables, potato, groundnut, grape, peach, pineapple	30 L (2013)	Also a granular formulation with lower hazard registered	EU: Yes USA: Voluntary cancellation (H & E)
715	Volamiphos 40% EC	Fenamiphos 400 g/l	WHO class Ib				
1056	Moz Fenamiphos 400 SC	Fenamiphos 400 g/l	WHO class Ib				

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
1115	Vet Fume B	Formaldehyde 370 g/l	Carcinogen	Disinfectant	1660 (2010) 4060 (2011) 1910 (2012) 3525 (2013)		EU: No (NS) USA:Yes
746	Crop Guard 90% EC	Furfural 900 g/l	WHO class Ib	Vegetables, tobacco, flowers, maize, groundnut	200 (2013)		EU: No (NS) USA: Yes
1163	Chemaron 58% SL	Methamidophos 585 g/l	WHO Ib; Rott. Annex III	Cotton, tobacco, vegetables	34760 L (2010) 13050 L (2011) 37832 L (2012) 28556 L (2013)		EU: No (RE)[5] USA:No; voluntary cancellation
1163	Chemeron 58% SL	Methamidophos 585 g/l	WHO Ib; Rott. Annex III				
1199	Sniper 58.5% SL	Methamidophos 585 g/l	WHO Ib; Rott. Annex III				
639	Volmet 58,5% SL	Methamidophos 585 g/l	WHO Ib; Rott. Annex III				
361	Mesurol 80 WP	Methiocarb 800 g/kg	WHO class Ib	Maize, groundnut, potato, vegetables, citrus	0	Also formulation with lower concentration registered	EU: Yes USA: Yes
1198	Methomex 90% SP	Methomyl 900 g/kg	WHO class Ib	Vegetables, tobacco, cereals, flowers	500 kg (2012) 1000 kg (2013)	Also formulation with lower concentration registered	EU: Yes USA: Yes
480	Delta Super 25,75% EC	Monocrotophos 250 g/l (+ Deltamethrin 7,5 g/l)	Rott. Annex III	Cotton, maize, tobacco	0		EU: No (NS) USA: No (cancelled in 1991)
478	Zipper Super 28% EC	Monocrotophos 250 g/l (+ Cypermethrin 30 g/l)	Rott. Annex III				
454	Monopec 40% SL	Monocrotophos 400 g/l	WHO Ib; Rott. Annex III				
1151	Monocrotophos 40% EC	Monocrotophos 400 g/l	WHO Ib; Rott. Annex III				
1185	Oxadate 31% SL	Oxamyl 310 g/l	WHO class Ib	Tobacco, sugarcane,	500 kg (2010)		EU: Yes

[5] RE = not registered because registration expired and was not renewed

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
810	Vydate 31% SL	Oxamyl 310 g/l	WHO class Ib	fruits, vegetables, groundnut	300 kg (2011) 400 kg (2012)		USA: Yes
1065	Moz Terbufos 15% GR	Terbufos 150 g/kg	WHO class Ia	Maize, sorghum, potato, beans	0		EU: No (NS) USA:Yes
1167 822	Ratikill 80% AB Ratil 80% AB	Zinc phosphide 800 g/kg Zinc phosphide 800 g/kg	WHO class Ib WHO class Ib	Rodents	0		EU: Yes USA:Yes
Total	*[57/646]*	*[24/225]*					
Pesticides not registered, but used in Mozambique and complying with the HHP criteria							
--	DDT 50% WP	DDT	Stockh. Annex B; Rott. Annex III	Malaria mosquito control	0 (but use of existing stocks)		EU: No (P)[6] USA: No
--	Brometo de metilo	Methyl bromide	Montreal Protocol	Quarantine treatments (stored products)	0 (but use of existing stocks)		EU: No (H) USA: Yes
Total		*[2]*					
Registered pesticides not complying with the JMPM criteria, but "coming close"							
570	Volcano 2,4 D 72% SL	2,4-D dimethylamine 720 g/l	WHO class II, but dermal hazard close to Ib	Sugar cane, coffee, cocoa, rice, palm trees.	47000 L (2010) 32600 L (2011) 52000 L (2012) 19600 L (2013)		EU: No USA: Yes
1063	Moz Paraquat 20% SL	Paraquat 200 g/l	WHO Class II but chronic toxicity alert; dermal hazard close to Class Ib; very low AOEL[7]	Forestry, fruits, vegetables, cotton, coffee, tea, flowers, banana, sugar cane,	22700 L (2010) 35100 L (2011) 17952 L (2012)		EU: No (A)[8] USA: Yes

[6] P = not registered because all use is prohibited in the EU

[7] AOEL = Acceptable Operator Exposure Level

[8] A= not registered because registration annulled by the Court

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
1303	Paracot 20% SL	Paraquat 200 g/l	WHO Class II but chronic toxicity alert; dermal hazard close to Class Ib; very low AOEL	pasture, potato	18440 L (2013)		
1262	Para-Cure 20% SL	Paraquat 200 g/l	WHO Class II but chronic toxicity alert; dermal hazard close to Class Ib; very low AOEL				
458	Paraxone 20% SL	Paraquat 200 g/l	WHO Class II but chronic toxicity alert; dermal hazard close to Class Ib; very low AOEL				
764	Volquato 20% SL	Paraquat 200 g/l	WHO Class II but chronic toxicity alert; dermal hazard close to Class Ib; very low AOEL				
1181	Gramozat 20% SL	Paraquat 200 g/l	WHO Class II but chronic toxicity alert; dermal hazard close to Class Ib; very low AOEL				
544	Ficam 80% WP	Bendiocarb 800 g/kg	WHO class II, but oral hazard close to Class Ib	Malaria mosquito control	5810 kg (2010) 14560 kg (2011) 30000 kg (2013)		EU: No (NS) USA: No; voluntary cancellation
735	Tocaia 80% WP	Bendiocarb 800 g/kg	WHO class II, but oral hazard close to Class Ib				
884	Avisnail 5% RB	Carbaryl 20 g/kg (+metaldehyde 30 g/kg	Carcinogen (see Annex I)	Cotton, potato, maize, sorghum, tobacco, groundnut, vegetables	400 kg (2010) 4200 kg (2011) 2200 kg (2012) 2600 kg (2013)		EU: No (H & E) USA: Yes
811	Supona 30% EC	Chlorfenvinphos 300 g/l	WHO class II, but oral hazard close to Class Ib	Veterinary uses	600 L (2012) 812 L (2013)		EU: No (NS) USA: No

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
816	Dazzel N.F 30% EC	Diazinon 300 g/l	WHO class II, but dermal hazard close to Class Ib	Veterinary uses	18 L (2010) 24 L (2011) 30 L (2012) 64 L (2013)		EU: No (H) USA: Yes
1155	Dichlorvos 10% EC	Dichlorvos (DDVP)100 g/l	WHO class II, but dermal and oral hazard close to Class Ib	Stored grains, vegetables, domestic use, veterinary use	1411 L (2010) 1462 L (2011) 2400 L (2012) 4000 L (2013)	More concentrated formulations in HHP shortlist above.	EU: No (H) USA: Yes
985	Nuvan Profi 12,4% AE	Dichlorvos 124 g/l	WHO class II, but dermal and oral hazard close to Class Ib				
986	Metrad 75% WG	Diuron 400 g/kg (+metribuzin 360 g/kg)	Carcinogen (see Annex I)	Sugarcane, cotton, macadamia nuts, coffee, banana, pineapple, wheat, tea, coconut, fruits trees, cocoa, rubber tree, industrials areas	47368 L (2010) 54140 L (2011) 58900 L (2012) 44660 L (2013)		EU: Yes USA: Yes
461	Dipec 80% WP	Diuron 800 g/kg	Carcinogen (see Annex I)				
849	Volcano Diuron 80% WG	Diuron 800 g/kg	Carcinogen (see Annex I)				
532	Volcano Diurão 800 SC	Diuron 800 g/l	Carcinogen (see Annex I)				
1061	Moz Diuron 80% SC	Diuron 800 g/l	Carcinogen (see Annex I)				
1211	Iprodione 25,5% SC	Iprodione 255 g/l	Carcinogen (see Annex I)	Vines, fruit trees, vegetables	12 L (2013)		EU: Yes USA: Yes
1101	Milthane Super 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)	Tobacco, vegetables, pineapple, ornamentals, fruit trees, potato, groundnut, vines , cereals, nuts, olive, coffee, soybean	68890 kg (2010) 77740 kg (2011) 30500 kg (2012) 59570 kg (2013)		EU: Yes USA: Yes
663	Volcano Crater MX 70% WP	Mancozeb 100 g/kg (+metalaxyl 600 g/kg)	Carcinogen (see Annex I)				
508	Etylit MZ 70% WP	Mancozeb 350 g/kg (+fosetyl-aluminium 350 g/kg)	Carcinogen (see Annex I)				
1236	Crater 455 SC	Mancozeb 455 g/l	Carcinogen (see Annex I)				
477	Megatop 50,5% WP	Mancozeb 465 g/kg (+cymoxanil 40 g/kg)	Carcinogen (see Annex I)				
1075	Dithane NT 60% OS	Mancozeb 600 g/kg	Carcinogen (see Annex I)				

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
875	Volcano Crater MX 72% WP	Mancozeb 640 g/kg (+ Metalaxyl 80 g/kg)	Carcinogen (see Annex I)				
546	Ridomil Gold 68% WP	Mancozeb 640 g/kg (+metalaxyl 40 g/kg)	Carcinogen (see Annex I)				
472	Ekyp MZ 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)	Carcinogen (see Annex I)				
823	Mascot 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)	Carcinogen (see Annex I)				
1136	Metaman FAE PM 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)	Carcinogen (see Annex I)				
1087	Neltylxyl 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)	Carcinogen (see Annex I)				
844	Ridomil Gold MZ 68 WG	Mancozeb 640 g/kg (+metalaxyl-M 40 g/kg)	Carcinogen (see Annex I)				
1045	Moz Controller	Mancozeb 700 g/kg (+cymoxanil 60 g/kg)	Carcinogen (see Annex I)				
1307	Cotzeb 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				
1162	Curethane 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				
1078	Dithane NT 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				
1143	Mazole 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				
1133	Policar MZ 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				
1221	Ventum 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				
534	Volcano mancozeb 800 WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				
457	Mancopec 80% WP	Mancozeb 800 g/kg	Carcinogen (see Annex I)				

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
466	Metacidine 40% WP	Methidathion 400 g/kg	WHO class II, but oral hazard close to Class Ib	Cotton, tobacco, sugar cane, vegetables, maize	0		EU: No (NS) USA: No; voluntary cancellation in progress
646	Mesurol Super Snail Pellets 1.5% RB	Methiocarb 5 g/kg+	WHO class II, but oral hazard close to Class Ib	Maize, groundnut, potato, vegetables, citrus	0	More concentrated formulations in HHP shortlist above.	EU: Yes USA: Yes
887	Volomyl 20% SL	Methomyl 200 g/l	WHO class II, but oral hazard close to Class Ib	Maize, groundnut, potato, vegetables, citrus, cotton, tobacco, flowers,	550 L (2012)	More concentrated formulations in HHP shortlist above.	EU: Yes USA: Yes
463	Rikki 20% SL	Methomyl 200 g/l	WHO class II, but oral hazard close to Class Ib				
1105	Volxyl 24% EC	Oxyfluorfen 240 g/l	Carcinogen (see Annex I)	Cotton, soybean, groundnut, vegetables, citrus, pine trees, eucalyptus trees	900 L (2010) 1200 L (2012)		EU: Yes USA: Yes
1131	King Insectos Voadores	Permethrin 0,4 g/kg (+d-Allethrin 0,82 g/kg +piperonyl butoxide 3,3 g/kg)	Carcinogen (see Annex I)	Stored grain, public health and domestic use	4958 L (2010) 27820 L (2011) 5000 L (2013)		EU: No (E) USA: Yes
974	Majestic Ultra 50% EC	Permethrin 100 g/l (+pirimiphos methyl 400 g/l)	Carcinogen (see Annex I)				
967	Cooper Aerosol Fly and Mosquito Killer	Permethrin 15 g/kg (+piperonyl butoxide 15 g/kg)	Carcinogen (see Annex I)				
1132	King Insectos Rastejantes	Permethrin 2,5 g/kg (+pyrethrins 1 g/kg)	Carcinogen (see Annex I)				
1123	Majestic super 2% DP	Permethrin 3 g/kg (+pirimiphos methyl 16 g/k)	Carcinogen (see Annex I)				
629	Super Guard Dust 2% DP	Permethrin 4 g/kg (+pirimiphos methyl 16 g/kg)	Carcinogen (see Annex I)				

Reg. no.	Trade name	Active ingredient (a.i.)	Reason for identification as potential HHP	Registered uses in Mozambique (summary)	Import volumes (2010 – 2013)	Notes	Registration status of a.i. elsewhere[1]
163	Larvin 37,5% SC	Thiodicarb 375 g/l	WHO class II, but very close to Class Ib	Cotton	0		EU: No (H & E) USA: Yes
Total	*[54]*	*[16]* *(of which 3 a.i.'s already listed in HHP shortlist above)*					

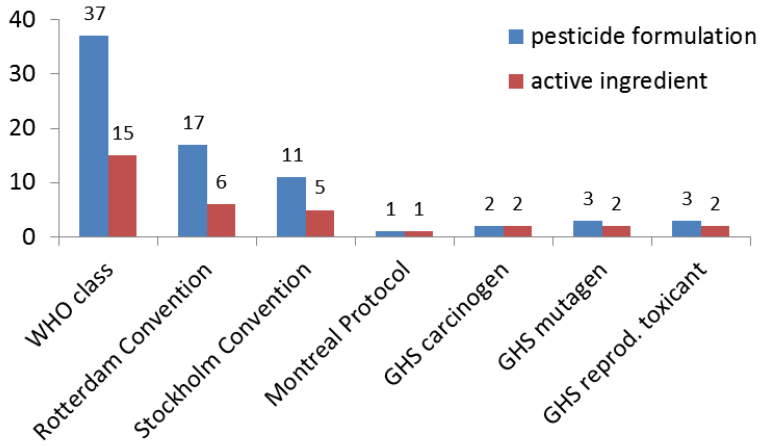

Figure 4. The number of identified highly hazardous pesticides (HHPs) in Mozambique according to the various JMPM criteria. Note that a pesticide may be identified as HHP based on more than one criterion.

3.3 Identification of pesticides "coming close" to HHPs

Using the criteria listed in Section 2.1, 54 formulated pesticide products containing 16 different active ingredients were identified as "coming close" to being an HHP (Figure 3 and Table 6). Of the 16 active ingredients, 13 were not listed under the HHPs.

Pesticide products were most often classified as being "close to" HHPs based on the acute oral or dermal toxicity of the formulations. In addition, the carcinogenicity evaluations of 16 active ingredients did not result in similar conclusions between the EU and the US-EPA. Generally, these pesticides which were evaluated as likely or probable carcinogens by the US-EPA, but not by the EU. Seven of the 16 active ingredients were considered a sufficiently great concern for Mozambique to include them under the group of pesticides "coming close" to HHPs (see Annex 1 for the justification).

In the case of paraquat, the WHO Classification notes in addition that it "*has serious delayed effects if absorbed. It is of relatively low hazard in normal use but may be fatal if the concentrated product is taken by mouth or spread on the skin*" (WHO, 2010). The occupational hazard of paraquat is confirmed by the very low Acceptable Operator Exposure Level defined in the EU (PPDB, 2012).

3.4 Registrations elsewhere

In national decision making on the continuation or modification of the registration of a HHP, it may be useful to review how other, reputable, registration authorities have evaluated the pesticide and what final registration decision they have taken.

In this step of the project, a quick search was conducted of the registration status in the EU and the USA of all pesticides listed in Table 6. This shows that some pesticides listed as HHP in Mozambique are not registered, or are being phased out, in both the EU and the USA (i.e. 9 active ingredients of HHPs and 3 additional ones for the "close to" HHPs). In some cases, this was for health and/or environmental reasons, but in others because the registration dossier was incomplete or because the pesticide was never submitted for registration in the first place. The

majority of the pesticides listed in Table 6, however, is still registered in either the EU or the USA, or in both.

When deciding on risk reduction measures for HHPs in Mozambique, including possible phase-out of certain products, it is therefore important to evaluate why exactly other registration authorities have decided not to register a pesticide; or if they have registered the pesticide, under which conditions it is allowed. These justifications and conditions should then be compared to the – actual or expected – use situation in Mozambique to evaluate whether the pesticide can continue to be used in the country, and with what possible restrictions.

3.5 Import statistics

The volumes of pesticides identified as HHPs and "coming close" to HHPs that were imported into Mozambique in the period 2010 – mid-2012 are listed in Table 6. The main objective of reviewing the import statistics is to identify which pesticides are likely not used (anymore) in the country, and for which no use surveys or additional hazard/risk assessments (Project Step 2) need to be conducted.

For 21 out of the listed 38 HHP-and "close to" HHPs active ingredients, no pesticide products were imported at all. For another seven active ingredients, less than 250 kg or litres were imported annually, and these would have a relatively low priority for further use surveys.

The most imported HHPs are products containing aluminium phosphide, benomyl, dichlorvos, difethialone, endosulfan, formaldehyde and metamidophos, with average annual imports greater than 2000 kg or litres; the most imported pesticides "coming close" to HHPs are 2,4-D dimethylamine, bendiocarb, diuron, mancozeb, paraquat and permethrin.

4 Conclusion

4.1 Methodology

The approach used for this first step of the project was entirely desk-based. It consisted of comparing all pesticide products registered in Mozambique against the criteria for highly hazardous pesticides (HHPs) as defined by the FAO/WHO Joint Meeting on Pesticide Management (JMPM). Since no international databases exist of HHPs, various reputable data sources were used to verify the criteria for each registered pesticide.

Overall, this approach allowed the assessment of the large majority of pesticide products registered in Mozambique. Some data gaps were identified, however, mainly for microbial pesticides, adjuvants/synergists and repellents. These pesticides could not be evaluated against all HHP criteria. But because these groups are generally of low hazard, it is not very likely that HHPs would have been missed.

On the other hand, a limited number of "regular" chemical pesticides could not be evaluated either for some criteria, using the data sources chosen for this study. Data were lacking mainly with respect to chronic toxicity (carcinogenicity, mutagenicity and reproductive toxicity) and for characteristics to identify persistent organic pollutants (POPs). Therefore, it cannot be excluded that the list of HHPs would be slightly longer if data would have been available for all pesticides.

The assessment of import volumes is very useful to distinguish between pesticides which have been registered but are not used in Mozambique, and those that are. This greatly helps to reduce the short-list of HHPs which require further use and exposure surveys and/or hazard/risk assessments.

4.2 Short-list of HHPs

The main objective of this first step of the project was to identify highly hazardous pesticides (HHPs) that are registered and used in Mozambique, and prepare a short-list of products that require further surveys on use and exposure and/or risk assessments. It is on the basis of the combined information from theoretical hazard assessments, more realistic risk assessments and actual use and exposure information that the Ministry of Agriculture can make informed decisions on further authorization of use of these HHPs.

This first step therefore results in a short-list on which to focus activities under Step 2 of the project. Based on the evaluation of HHP criteria discussed above, and the import statistics, it is recommended to focus the use and exposure surveys in the field, and further hazard and risk assessments, on the pesticide products listed in Table 7. These are all pesticides which average annual imports of more than approximately 250 kg or L. Identified HHPs that are imported in lower volumes are not given priority for Step 2 activities.

In total, Table 7 consists of 76 pesticide products containing 18 different active ingredients. These represent 10% of registered pesticide products and 8% of registered active ingredients in Mozambique.

Table 7. Short-list of highly hazardous pesticides (HHPs) and pesticides "coming close" to HHPs, prioritized for further study in Step 2 of the project.

Reg. no.	Trade name	Active ingredient
HHPs		
1172	Fumate 56% FT	Aluminium Phosphide 560 g/kg
1054	Moz Aluminium Phosphide Pellets	Aluminium Phosphide 560 g/kg
581	Phosgard 56% FT	Aluminium phosphide 560 g/kg
773	Falfume 57% FT	Aluminium Phosphide 570 g/kg
1071	Moz Aluminium Phosphide Tablets	Aluminium Phosphide 570 g/kg
1129	Quickphos 57% FT	Aluminium Phosphide 570 g/kg
1080	Biophos 57% FW	Aluminium phosphide 570 g/kg
1028	Celphos 57% FT	Aluminium phosphide 570 g/kg
664	Volcano Aluminium Phosphide 57% FT	Aluminium phosphide 570 g/kg
467	Benopec 50% WP	Benomyl 500 g/kg
772	Volcano Demeter 50% WP	Benomyl 500 g/kg
1202	Divos 100% EC	Dichlorvos 1000 g/l
774	Falcovos 100% EC	Dichlorvos 1000 g/l
984	Nuvam 100% EC	Dichlorvos 1000 g/l
944	Finale Rat And Mouse Grain Bait	Difethialone 0,025 g/kg
969	Finale Rat And Mouse Pellets	Difethialone 0,025 g/kg
943	Finale Rat And Mouse Wax Bait	Difethialone 0,025 g/kg
719	Ratex Pellts	Difethialone 0,025 g/kg
1027	Endocel 35% EC	Endosulfan 350 g/l
447	Endopec 35% EC	Endosulfan 350 g/l
825	Enticer 35% EC	Endosulfan 350 g/l
605	Volcano Endosulfão 35% EC	Endosulfan 350 g/l
1115	Vet Fume B	Formaldehyde 370 g/l
1163	Chemaron 58% SL	Methamidophos 585 g/l
1199	Sniper 58.5% SL	Methamidophos 585 g/l
639	Volmet 58,5% SL	Methamidophos 585 g/l
1198	Methomex 90% SP	Methomyl 900 g/kg
1185	Oxadate 31% SL	Oxamyl 310 g/l
810	Vydate 31% SL	Oxamyl 310 g/l
"close to" HHPs		
570	Volcano 2,4 D 72% SL	2,4-D dimethylamine 720 g/l
1063	Moz Paraquat 20% SL	Paraquat 200 g/l
1303	Paracot 20% SL	Paraquat 200 g/l
1262	Para-Cure 20% SL	Paraquat 200 g/l
458	Paraxone 20% SL	Paraquat 200 g/l
764	Volquato 20% SL	Paraquat 200 g/l
1181	Gramozat 20% SL	Paraquat 200 g7l

Reg. no.	Trade name	Active ingredient
544	Ficam 80% WP	Bendiocarb 800 g/kg
735	Tocaia 80% WP	Bendiocarb 800 g/kg
884	Avisnail 5% RB	Carbaryl 20 g/kg (+metaldehyde 30 g/kg
811	Supona 30% EC	Chlorfenvinphos 300 g/l
1155	Dichlorvos 10% EC	Dichlorvos (DDVP)100 g/l
985	Nuvan Profi 12,4% AE	Dichlorvos 124 g/l
986	Metrad 75% WG	Diuron 400 g/kg (+metribuzin 360 g/kg)
461	Dipec 80% WP	Diuron 800 g/kg
849	Volcano Diuron 80% WG	Diuron 800 g/kg
532	Volcano Diurão 800 SC	Diuron 800 g/l
1061	Moz Diuron 80% SC	Diuron 800 g/l
1101	Milthane Super 80% WP	Mancozeb 800 g/kg
663	Volcano Crater MX 70% WP	Mancozeb 100 g/kg (+metalaxyl 600 g/kg)
508	Etylit MZ 70% WP	Mancozeb 350 g/kg (+fosetyl-aluminium 350 g/kg)
1236	Crater 455 SC	Mancozeb 455 g/l
477	Megatop 50,5% WP	Mancozeb 465 g/kg (+cymoxanil 40 g/kg)
1075	Dithane NT 60% OS	Mancozeb 600 g/kg
875	Volcano Crater MX 72% WP	Mancozeb 640 g/kg (+ Metalaxyl 80 g/kg)
546	Ridomil Gold 68% WP	Mancozeb 640 g/kg (+metalaxyl 40 g/kg)
472	Ekyp MZ 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)
823	Mascot 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)
1136	Metaman FAE PM 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)
1087	Neltylxyl 72% WP	Mancozeb 640 g/kg (+metalaxyl 80 g/kg)
844	Ridomil Gold MZ 68 WG	Mancozeb 640 g/kg (+metalaxyl-M 40 g/kg)
1045	Moz Controller	Mancozeb 700 g/kg (+cymoxanil 60 g/kg)
1307	Cotzeb 80% WP	Mancozeb 800 g/kg
1162	Curethane 80% WP	Mancozeb 800 g/kg
1078	Dithane NT 80% WP	Mancozeb 800 g/kg
1143	Mazole 80% WP	Mancozeb 800 g/kg
1133	Policar MZ 80% WP	Mancozeb 800 g/kg
1221	Ventum 80% WP	Mancozeb 800 g/kg
887	Volomyl 20% SL	Methomyl 200 g/l
463	Rikki 20% SL	Methomyl 200 g/l
1105	Volxyl 24% EC	Oxyfluorfen 240 g/l
1131	King Insectos Voadores	Permethrin 0,4 g/kg (+d-Allethrin 0,82 g/kg +piperonyl butoxide 3,3 g/kg)
974	Majestic Ultra 50% EC	Permethrin 100 g/l (+pirimiphos methyl 400 g/l)
967	Cooper Aerosol Fly and Mosquito Killer	Permethrin 15 g/kg (+piperonyl butoxide 15 g/kg)

Reg. no.	Trade name	Active ingredient
1132	King Insectos Rastejantes	Permethrin 2,5 g/kg (+pyrethrins 1 g/kg)
1123	Majestic super 2% DP	Permethrin 3 g/kg (+pirimiphos methyl 16 g/k)
629	Super Guard Dust 2% DP	Permethrin 4 g/kg (+pirimiphos methyl 16 g/kg)

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WHO (2012) WHO specifications for pesticides used in public health. (Accessed at various instances between August and October 2012). World Health Organization, Geneva. [http://www.who.int/whopes/quality/newspecif/en/]

Annex 1: Carcinogenicity – ambiguous cases

This annex lists the pesticides for which the carcinogenicity evaluations by WHO/IARC, EPA and the EU did not result in the same outcome. The final conclusion for the HHP assessment in Mozambique is in the last column of the table. Those considered a carcinogen equivalent to GHS class 1A and 1B are listed as "Yes" and included under the section *Registered pesticides not complying with the JMPM criteria, but "coming close"* of Table 6 of this report.

Active ingredient	Reviews: carcinogenic (similar to GHS 1A&1B) yes/no? [date of publication of review]				Conclusion for HHP identification. Carcinogenic (similar to GHS 1A&1B) yes/no?
	IARC	EPA carcinogenicity list	EU	WHO Classification	
Alachlor	Not evaluated	Yes: likely at high doses; not likely at low doses; [June 1997] Note: US registered	No; unlikely at doses attained in use (Carc[9]. = Cat. 2) [Jan 2007] Note: EU not registered	No – carcinogenicity mechanism not relevant to humans [2010]	No. US registered, and EU not registered. Most recent reviews conclude pesticide is not carcinogenic at relevant rates
Carbaryl	No [1987]	Yes: likely to be carcinogenic [Feb 2002] Note: US registered, but basic or extensive PPE required for handling and use ; wettable powders only packaged in water-soluble bags, to reduce cancer risk (amended RED[10], 2008)	No (Carc. = Cat. 2) [Sep 2006] Note: EU not registered; potential carcinogenic properties of the active substance is noted as a concern (Review report[11], 2006)	Not evaluated	Yes. EU not registered. US registered, but with PPE other risk mitigations

[9] Carc.: Carcinogenicity classification (EU)

[10] RED: Reregistration Eligibility Document (US – Environmental Protection Agency)

[11] Review report: Review report on active substances (EU - Standing Committee on the Food Chain and Animal Health)

Active ingredient	Reviews: carcinogenic (similar to GHS 1A&1B) yes/no? [date of publication of review]				Conclusion for HHP identification. Carcinogenic (similar to GHS 1A&1B) yes/no?
	IARC	EPA carcinogenicity list	EU	WHO Classification	
Chlorothalonil	Not evaluated	Yes: likely to be carcinogenic [Oct 1997] Note: US registered. Dietary cancer risk due to HCB impurities in chlorothalonil; limit < 40 ppm is acceptable. (RED Factsheet[12] 1999)	No (Carc. = Cat. 2) [Sep 2006] Note: EU registered	Not evaluated	No; unless products in Mozambique contain high levels of HCB impurities Registered in both US and EU.
Diuron	Not evaluated	Yes: known/likely to be carcinogenic [July 1997] Note: US registered. However, occupational cancer risk of concern; i.e. use of backpack sprayers prohibited (RED, 2003)	No (Carc. = Cat. 2) [Jul. 2008] Note: EU registered	Not evaluated	Yes Explicit prohibition of use with backpack sprayers in US; so a concern for Mozambique
Epoxicionazol	Not evaluated	Yes: likely to be carcinogenic [Jan 2001] Note: US only an import tolerance; dietary risk acceptable; occupational risk not evaluated	No (Carc. = Cat. 2) [sep 2010] Note: EU registered	Not evaluated	No Registered in EU and tolerance in US.

[12] Factsheet: US – EPA pesticide registration factsheets

Active ingredient	Reviews: carcinogenic (similar to GHS 1A&1B) yes/no? [date of publication of review]				Conclusion for HHP identification. Carcinogenic (similar to GHS 1A&1B) yes/no?
	IARC	EPA carcinogenicity list	EU	WHO Classification	
Iprodione	Not evaluated	Yes: likely to be carcinogenic [Feb 1998] Note: US registered. However, all residential uses cancelled due to cancer risk concerns. Also, backpack sprayers, mixers should wear double layer PPE, masks and gloves. (RED, 1998)	No (Carc. = Cat. 2) [sep 2004] Note: EU registered	Not evaluated	Yes Registered in both EU and US. However, US proposed risk mitigation measures (PPE for sprayers/handlers and cancellation of residential uses) poses significant concern for Mozambican use situation.
Isoxaflutole	Not evaluated	Yes: likely to be carcinogenic [Sep 1997] Note: US registered.	No (Carc. not classified) [oct 2003] Note: EU registered	Not evaluated	No. Registered in both EU and US.
Kresoxim-methyl	Not evaluated	Yes: likely to be carcinogenic [Aug 1999] Note: US registered. But only on ornamental crops (Factsheet 1998)	No (Carc. = Cat. 2) [jan 2012] Note: EU registered	Not evaluated	No. Registered in both EU and US.
Mancozeb (cancer risk due to ETU metabolite)	Not evaluated	Yes: probable human carcinogen [Jul 1999] Note: US registered. Cancer risk below EPA thresholds; but (at least) layer PPE required; WP formulations only as water-soluble bags (RED 2005)	No (Carc. not classified) [july 2006] Note: EU registered	Not evaluated	Yes. Registered in both EU and US. However, US proposed risk mitigation measures (full PPE for sprayers/handlers and requirement for water-soluble bags for WPs) poses significant concern for Mozambican use situation.

Active ingredient	Reviews: carcinogenic (similar to GHS 1A&1B) yes/no? [date of publication of review]				Conclusion for HHP identification. Carcinogenic (similar to GHS 1A&1B) yes/no?
	IARC	EPA carcinogenicity list	EU	WHO Classification	
Metiram	Not evaluated	Yes: probable human carcinogen [Jul 1999] Note: US registered. (RED, 2005)	No (Carc. not classified) [july 2006] Note: EU registered (review report 2005: "no evidence of carcinogenic potential")	Not evaluated	No. Registered in both EU and US. Most recent EU review concludes pesticide is not carcinogenic
Oxadiazon	Not evaluated	Yes: likely to be carcinogenic [May 2001] Note: US registered. Cancer risks for occupational handlers of wettable-powder formulations of oxadiazon are of concern. Exposure scenarios of concern include mixing/ loading/ applying wettable powder formulations. To reduce these risks, the wettable powder formulations will be packaged in water-soluble packaging (WSP) only (RED Factsheet 2008)	No Carc. not classified. [jan 2010] Note: EU registered EFSA Conclusion (2010): "humans are not responsive to this class of non-genotoxic carcinogens and therefore, oxadiazon is unlikely to present a carcinogenic risk to humans"	Not evaluated	No. Registered in both EU and US. Most recent review indicates low cancer risk.
Oxyfluorfen	Not evaluated	Yes: likely to be carcinogenic [Mar 2010] Note: US registered. Cancer risk of handlers applicators / workers: Double layer Personal Protective Equipment (PPE) for all other mixers, loaders, and applicators; closed mixing/loading/ application systems required for use in several major crops.	No (Carc. not classified) [jan 2012] Note: EU registered EFSA Conclusion (2010): ... classification as Carc Cat 3 – *limited evidence of a carcinogenic effect* – was proposed by EFSA.	Not evaluated	Yes. Registered in both EU and US. However, US proposed risk mitigation measures (double PPE and closed systems) poses significant concern for Mozambican use situation.

Active ingredient	Reviews: carcinogenic (similar to GHS 1A&1B) yes/no? [date of publication of review]				Conclusion for HHP identification. Carcinogenic (similar to GHS 1A&1B) yes/no?
	IARC	EPA carcinogenicity list	EU	WHO Classification	
Permethrin	No [1991]	Yes: likely to be carcinogenic [Oct 2002] Note: US registered. In some application scenarios, cancer risk exceeds the threshold. WP and DP formulations require double layer PPE. (Factsheet, 2009).	No (Carc. not classified) Note: EU not registered. (due to incomplete dossiers, mainly for ecotox topics).	Not evaluated	Yes. Registered in US, but not in EU. Certain uses in US require extensive PPE – to be compared with Mozambique uses of permethrin.
Tetrachlorvinphos	No	Yes: likely to be carcinogenic [Mar 2002] No: Group C: possible human carcinogen [July 2006] Note: US registered.	No (no classification because no toxicological information) Note: EU not registered.	Not evaluated	No. Latest US evaluation does not place this pesticide in the HHP category
Thiabendazole	Not evaluated	Yes: Likely human carcinogen at high doses; not likely at low doses [Mar 2002] Note: US registered. "Carcinogenic risks at expected doses not pose a concern" (Factsheet, 2002)	No (Carc. not classified) Note: EU registered.	Not evaluated	No. Registered in both EU and US.
Thiodicarb (Note: rapid degradation to methomyl)	Not evaluated	Yes: Probable human carcinogen. [Jun 1996] Note: US registered. Relatively standard PPE requirements; no specific PPE to reduce carcinogenicity risk (RED, 1998)	No (Carc. not classified) Note: EU not registered. Overall, thiodicarb does not show genotoxic or carcinogenic potential (EFSA Opinion, 2005)	Not evaluated	No. Most recent EU review concludes pesticide is not carcinogenic

Reducing Risks of Highly Hazardous Pesticides in Mozambique

Step 2 – Survey of pesticide use practices in selected cropping systems

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[9 July 2014]

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FAO Disclaimer

Contents

1. Introduction

A project entitled *Reducing Risks of Highly Hazardous Pesticides (HHPs) in Mozambique* was initiated by the Government of Mozambique with the objective to reduce the greatest risks associated with pesticide use in the country. This project is implemented with technical support of FAO's Pesticides Management Unit and is funded by SAICM Quick Start Programme Trust Fund.

The ultimate goal is to develop and implement an "HHP Risk Reduction Action Plan" for the most dangerous pesticides and use situations, resulting over time in the implementation of a variety of risk reduction measures based on a review of use conditions. These may include the cancellation of specific registrations of HHPs, implementation of risk mitigation measures, appropriate use restrictions, development of alternative pest management strategies, promotion of good agricultural practices, or phase-out of specific pesticides.

In the first step of the project, a review of all pesticides registered in Mozambique was carried out and a shortlist of highly hazardous pesticides was established. This shortlist was based on an assessment of the hazards of the pesticides, based on criteria established by the FAO/WHO Joint Meeting on Pesticide Management (Come & Van der Valk, 2014).

During the second step of the project, a use survey was carried out in selected regions and cropping systems in Mozambique. The main goal of the survey was to identify the conditions under which pesticides are being used in the country and their contribution to potential risks for human health and the environment.

The third step of the project consisted of a stakeholder consultation to further discuss the use and risks of highly hazardous pesticides in Mozambique and fine-tune the shortlist based on the survey results and the expertise and experience of stakeholders.

2. Methodology

2.1 Cropping systems

Cropping systems were selected for the study in which pesticides are used on a regular basis and/or HHPs were known to be applied. These are vegetables, cotton and tobacco, generally managed by smaller subsistence farmers. Farmers were surveyed in eight different regions of Mozambique, which was expected to provide a broad sample of pesticide use practices in the country (Table xx). In the regions where the commodity crops cotton and tobacco are grown, limited information was also collected for other crops grown by the same farmers.

In addition, pesticide use practices were also assessed in bananas and sugar cane, both plantation crops run by larger commercial farms.

Table 1 Geographical distribution and cropping systems covered by the pesticide use survey

Region	Number of districts concerned	Crops included in the survey	Number of farmers interviewed	Survey period (2013)
Maputo Ciudade	2	Vegetables	40	1–14 February
Maputo Provincia	3	Vegetables	28	31 Jan. – 8 Feb.
Gaza	2	Vegetables	30	1–19 February
Zambésia	5	Cotton Tobacco (Other crops)	15 19 (34)	29 Jan. – 14 Feb.
Tete	8	Cotton Tobacco (Other crops)	23 50 (73)	16–25 January
Nampula	4	Cotton (Other crops)	20 (20)	16 Jan. – 2 Feb.
Niassa	5	Tobacco Cotton (other crops)	25 11 (36)	17 Jan. – 1 Feb.
Cabo Delgado	4	Cotton (Other crops)	64 (64)	n.a.
Total	33		325	

Surveys were conducted in January and February 2013, during the rainy season. During this period, vegetables are grown and harvested, cotton has been sown and the plant is in early stages of development, and tobacco approaches the harvest.

2.2 Survey questionnaires

The surveys were conducted using a standard questionnaire, specific for each cropping system. The questionnaires were elaborated to obtain maximum information on pesticide use which could subsequently be used to assess the local risks of HHPs in Mozambique and evaluate the possibilities to introduce alternatives posing a lower risk. Various existing pesticide use or exposure surveys were reviewed (e.g. WHO, 2001; Amera & Abate, 2008; Rotterdam Convention, undated), as well as general guidance on development of this type of questionnaires (e.g. FAO, 1997). The first version of the questionnaire was tested among a

limited number of vegetable farmers around Maputo and various modifications were made to the final version.

The questionnaires followed a structure that was similar, though not identical, for all cropping systems:

1. Demographical socio-economic information
   - e.g.: location, sex, age, education, contact details
2. Crop information for the season 2012/2013 (vegetables, cotton, tobacco, plantation crops) and/or 2011/2012 (cotton, tobacco)
   - e.g.: type of crop, area cultivated, duration of cropping cycle
3. Pesticide application for the season 2012/2013 (vegetables, cotton, tobacco, plantation crops) and/or 2011/2012 (cotton, tobacco)
   - e.g.: name of applied pesticide(s), when applied, against which pest, application rate, number of applications per cropping cycle.
4. Pesticide product information
   - e.g.: type of formulation, type of packaging, label, where and how much purchased, costs
5. Pesticide application conditions
   - e.g.: who prepares the mixture and who applies the pesticide; source of advice on use; personal protective equipment, knowledge of label instructions; type of application equipment; management of empty containers
6. Alternative pest control methods
   - e.g.: awareness of alternative control methods; monitoring and spraying regime (for cotton)
7. Health effects
   - e.g.: if/when exposed to pesticides; decontamination; signs and symptoms of poisoning

The complete questionnaires are provided in Annex xx.

2.3 Interviewers

Interviews of farmers and pesticide distributors were performed by the plant protection officers of the Provincial Directorates of Agriculture. The interviewers were trained in a three-day session in which survey techniques and the data collection form were discussed in detail and subsequently tested in the field. Two training sessions were conducted in January 2013, in Nampula and Maputo, for five and three interviewers respectively.

2.4. Data entry and analysis

Data entry of questionnaire information was produced in Mozambique entered in excel datasets per province. The data was subsequently integrated and harmonised at FAO HQ and analysed using excel 2014.

3. Results

3.1 Socio-demographic coverage

Of the total of 325 farmer that were interviewed, 82% were male and 18% female. Most female farmers were encountered in vegetable production in Gaza and Maputo provinces (Figure xx). Only male farmers were interviewed in cotton in Tete and Zambesia provinces.

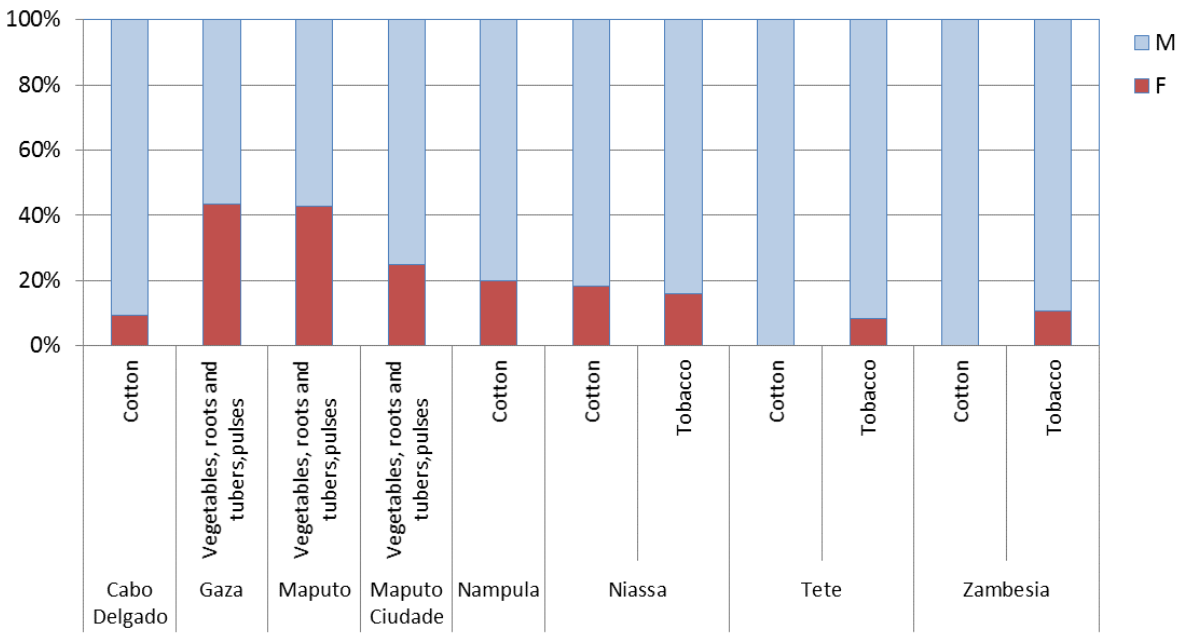


Figure 1 Gender distribution of interviewed farmers, per region and cropping system. F=female, M=male.

Overall, 68% of the interviewed farmers were between the age of 26 and 55. However, age distributions among cropping systems differed (Figure xx). Vegetable farmers were relatively older, with 60% of respondents being over 45 years of age. In contrast, cotton farmers were younger, with 35% under 35 years.

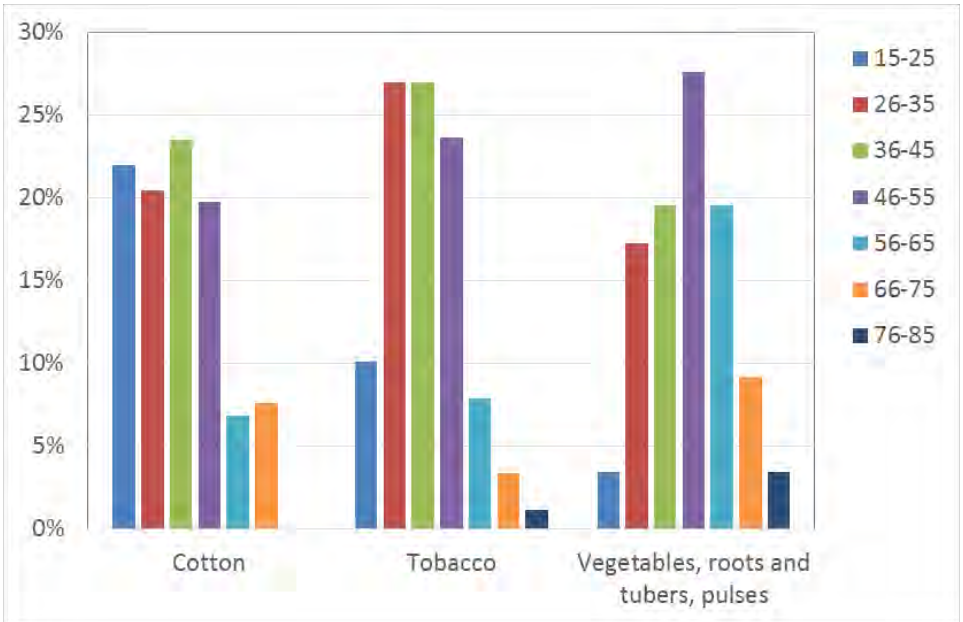


Figure 2 Gender distribution of interviewed farmers, per cropping system.

- The majority of farmers had either elementary education (33% of respondents) or had done level 5-10 (33%); 24% had no education at all. Education levels of respondents were fairly similar in Maputo, Gaza and Niassa. In Tete, Cabo Delgado and Nampula, education levels were on average slightly higher, while in Zambésia they were on average lower.

Table 2 *Number of farmers interviewed*

Region	Number	Gender		Education[2]						
		Male	Female	None	Elementary	Level 5-10	Level 11-12	Basic agrarian level	Medium agrarian level	Higher level
Maputo Ciudade	40	30	10	4	21	10	2	0	0	0
Maputo Provincia	28	16	12	7	12	7	0	0	0	0
Gaza	30	17	13	4	14	9	0	0	1	1
Zambésia	34	31[1]	2	19	11	3	0	0	0	0
Tete	73	69	4	15	22	34	2	0	0	0
Nampula	20	16	4	3	5	12	0	0	0	0
Niassa	36	30	6	13	16	7	0	0	0	0
Cabo Delgado	64	58	6	14	24	24	1	1	0	0
Total	*325*	*267*	*57*	*79*	*125*	*106*	*5*	*1*	*1*	*1*

[1] One interview with a production company; gender not indicated.
2 For 7 persons education level not indicated.

3.2. Crop distribution

Table 3 crop distribution per province in database

provinces	Cotton	Tobacco	Vegetables, roots and tubers,pulses
Cabo Delgado	100.00%	0.00%	0.00%
Gaza	0.00%	0.00%	100.00%
Maputo	0.00%	0.00%	100.00%
Maputo Ciudade	0.00%	0.00%	100.00%
Nampula	100.00%	0.00%	0.00%
Niassa	30.56%	69.44%	0.00%
Tete	34.25%	65.75%	0.00%
Zambesia	44.12%	55.88%	0.00%
Grand Total	**41.54%**	**28.31%**	**30.15%**

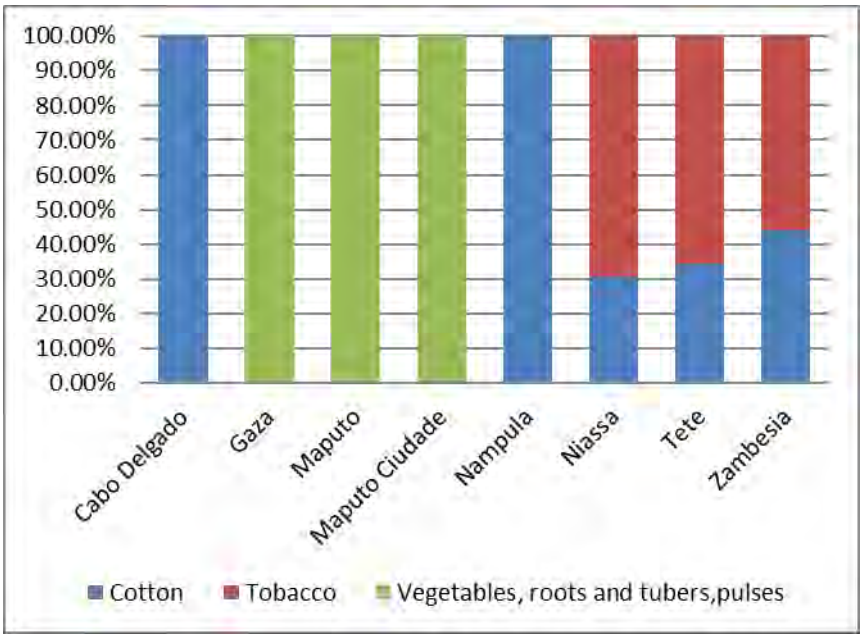


Figure 3 crop distribution per province

3.3. Use of pesticides

3.3.1. Use of pesticides

The majority of the respondents where applying themselves the pesticide, and this is true for all provinces surveyed. Therefore they were providing personal replies on their use of pesticides.
The surveys revealed that most of the farmers surveyed applied pesticides- only 17 of the 325 said they did not.

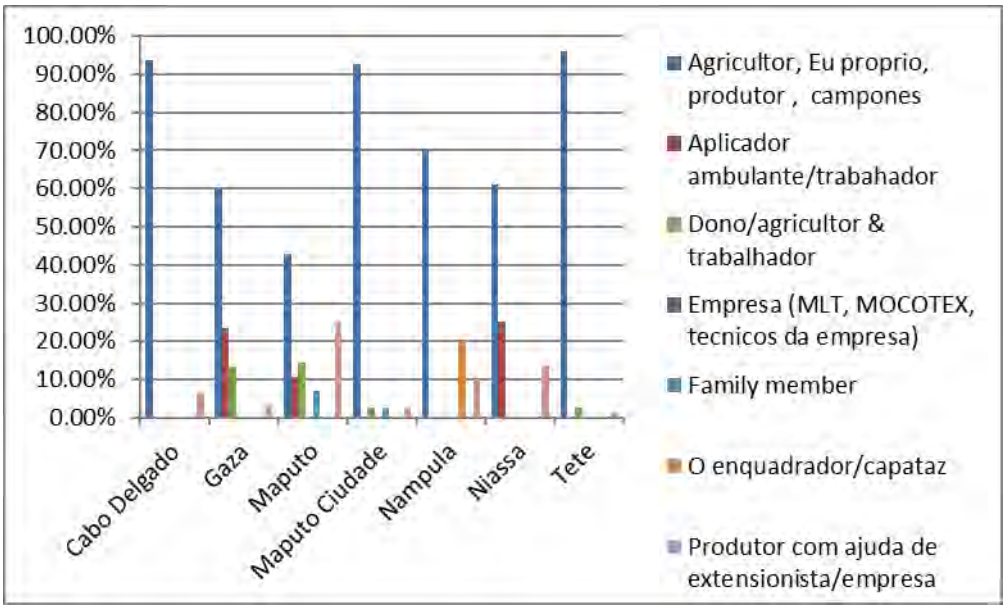


Figure 4 applicators of pesticide

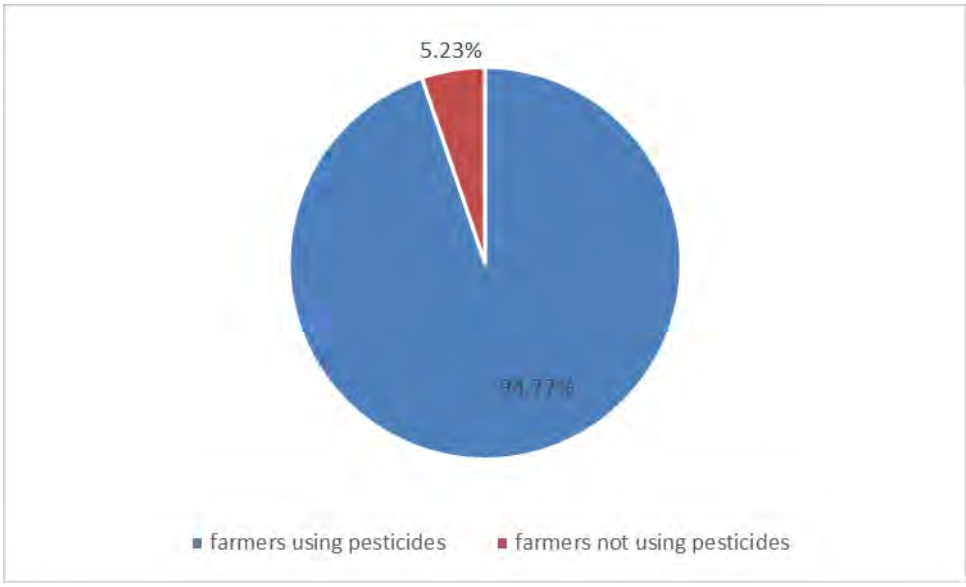


Figure 5 use of pesticide for farmer's part of the survey

3.3.2. Use of Highly Hazardous Pesticides (HHPs)

Farmers using HHPs (as per FAO-WHO 7 criteria) include almost 30% of the surveyed farmers. The HHP formulation that is most used is by far including methamidophos compound which is used by a great share of farmers particularly for vegetable crops. In addition, farmers reported overspraying vegetable crops as many as 14 timesper growing season.

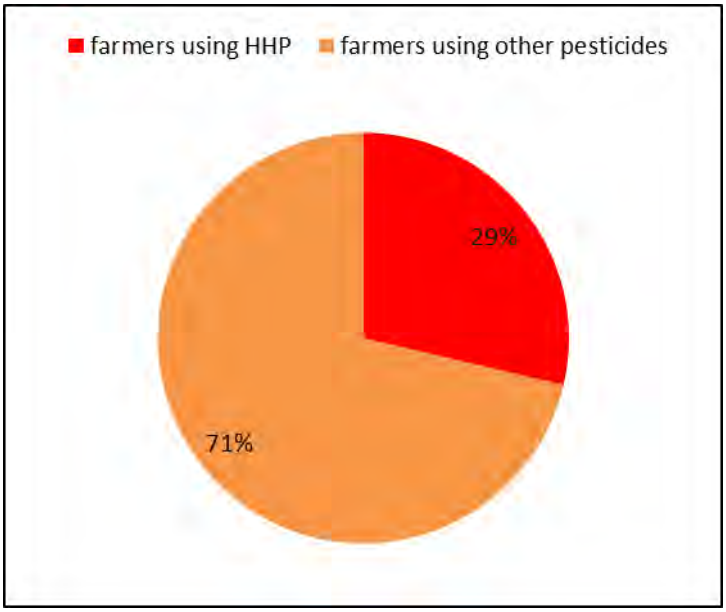


Figure 6 HHP users (out of farmers who apply pesticides)

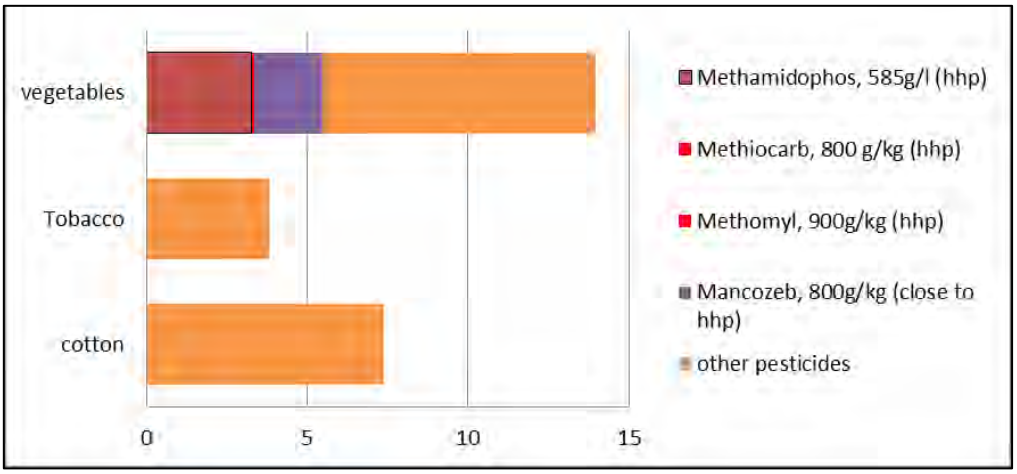


Figure 7 average applications of pesticides for farmers surveyed per crop

3.3.3. Training of farmers on pesticide use

At least half farmers did not receive training on pesticide use while making use of pesticides including HHPs.

Row Labels	Não	Sim	null	Grand Total
Cabo Delgado	60.94%	32.81%	6.25%	100.00%
Gaza	73.33%	26.67%	0.00%	100.00%
Maputo	46.43%	46.43%	7.14%	100.00%
Maputo Ciudade	55.00%	42.50%	2.50%	100.00%
Nampula	80.00%	20.00%	0.00%	100.00%
Niassa	47.22%	44.44%	8.33%	100.00%
Tete	43.84%	53.42%	2.74%	100.00%
Zambesia	5.88%	88.24%	5.88%	100.00%
Grand Total	**50.15%**	**45.54%**	**4.31%**	**100.00%**

3.3.5. Pesticide application equipment

The majority of pesticide applicators used manual sprayer (36%), followed by electric sprayer (with batteries); 33% and followed by inappropriate equipment such as watering can (13.5%) or other (unknown) means (12.5%).

Table 4 Pesticide application equipment

Provinces	Balde	Outros	Pulverizador de dorso manual	Pulverizador que funcionam a pilhas (e.x. Micro-Ulva)	Regador	no data
Cabo Delgado	0.00%	0.00%	0.00%	93.75%	0.00%	6.25%
Gaza	3.33%	0.00%	96.67%	0.00%	0.00%	0.00%
Maputo	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%
Maputo Ciudade	0.00%	0.00%	97.50%	0.00%	0.00%	2.50%
Nampula	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%
Niassa	0.00%	61.11%	5.56%	25.00%	0.00%	8.33%
Tete	0.00%	0.00%	24.66%	6.85%	60.27%	8.22%
Zambesia	0.00%	55.88%	2.94%	41.18%	0.00%	0.00%
Grand Total	**0.31%**	**12.62%**	**36.00%**	**33.23%**	**13.54%**	**4.31%**

3.3.6. Farmer reports of undue pesticide contamination

Farmers responses to the question: "are you receiving pesticides on clothes or skin, or in your eyes during using pesticides?" are summarised in the tables and figures below. At the national level (as sum) about half farmers surveyed reported that they noticed to receive pesticide on their clothes, bare skin or eyes when using pesticides, with some differences between provinces for different crops.

Table 5 Farmer reports of noticing of being contaminated by pesticides while using them

Provinces	Não, nunca	Sim	Sim, algumas vezes	Sim, muitas vezes	null
Cabo Delgado	20.31%	0.00%	62.50%	17.19%	0.00%
Gaza	66.67%	0.00%	23.33%	10.00%	0.00%
Maputo	28.57%	3.57%	60.71%	3.57%	3.57%
Maputo Ciudade	50.00%	17.50%	32.50%	0.00%	0.00%
Nampula	25.00%	0.00%	50.00%	25.00%	0.00%
Niassa	69.44%	0.00%	25.00%	2.78%	2.78%
Tete	63.01%	0.00%	26.03%	9.59%	1.37%
Zambesia	88.24%	0.00%	11.76%	0.00%	0.00%
Grand Total	**51.38%**	**2.46%**	**36.62%**	**8.62%**	**0.92%**

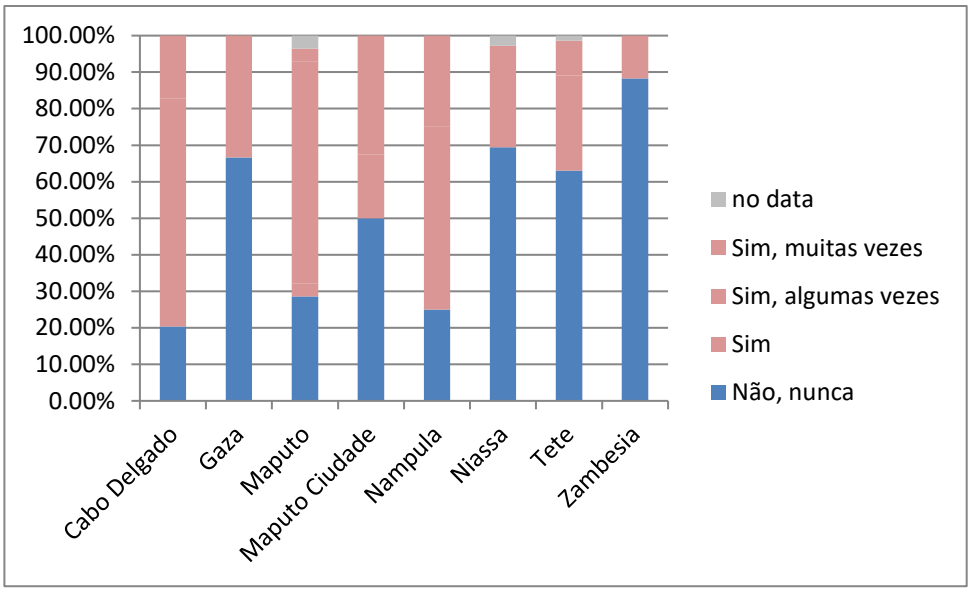
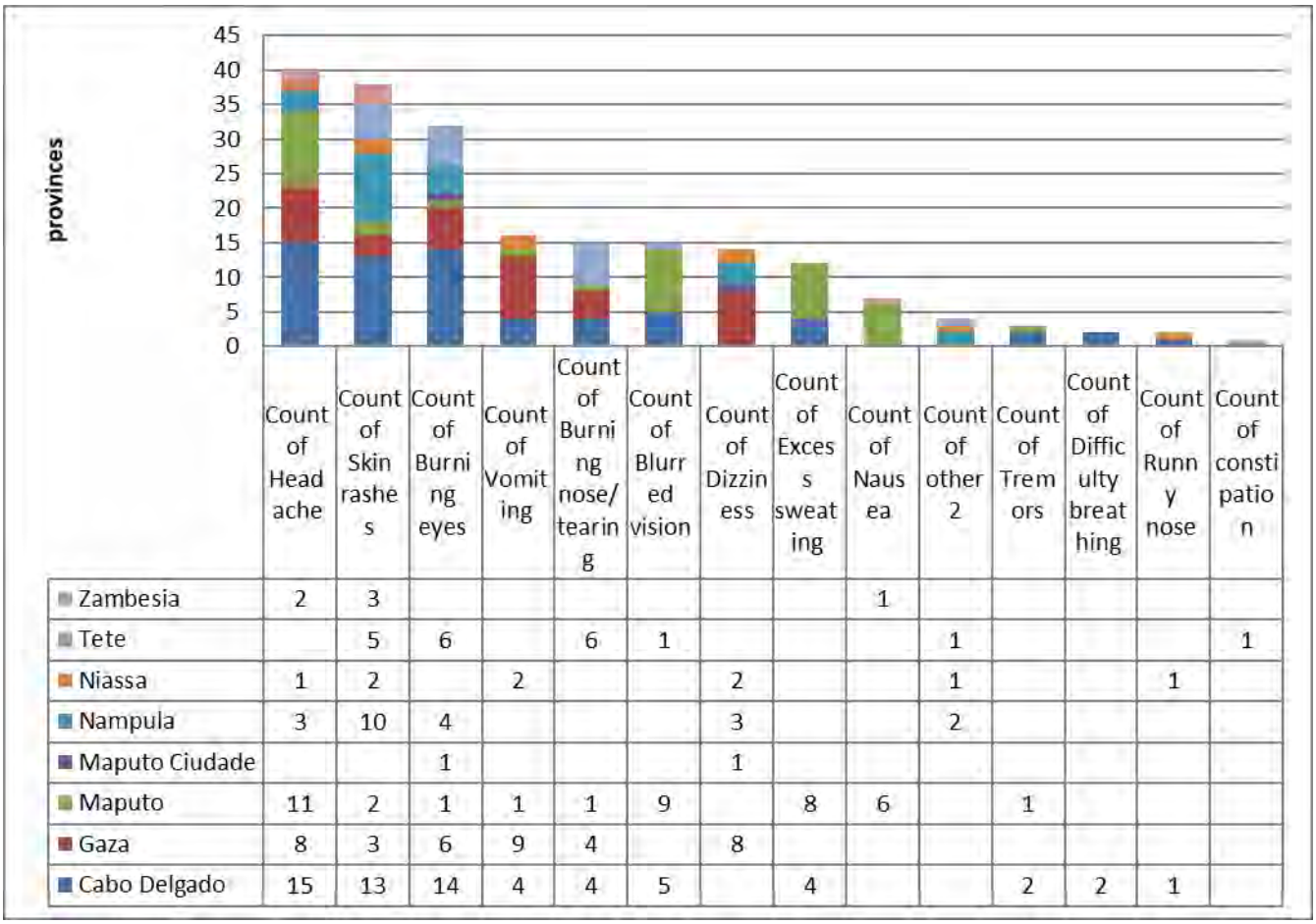


Figure 8 Farmer reports of noticing of being contaminated by pesticides while using them

3.3.7. Main health symptoms associated with pesticide use by farmers

Main health symptoms associated with pesticide use by farmers noticing symptoms were headaches, skin rashes, burning eyes, vomiting, burning nose, blurred vision, dizziness and excess sweating.



provinces	Count of Head ache	Count of Skin rashes	Count of Burning eyes	Count of Vomiting	Count of Burning nose/ tearing	Count of Blurred vision	Count of Dizziness	Count of Excess sweating	Count of Nausea	Count of other 2	Count of Tremors	Count of Difficulty breathing	Count of Runny nose	Count of constipation
Zambesia	2	3							1					
Tete		5	6		6	1				1				1
Niassa	1	2		2			2			1			1	
Nampula	3	10	4				3			2				
Maputo Ciudade			1				1							
Maputo	11	2	1	1	1	9		8	6		1			
Gaza	8	3	6	9	4		8							
Cabo Delgado	15	13	14	4	4	5		4			2	2	1	

Figure 9 Reported health symptoms of farmers per province after or during having used pesticides

3.3.8. Farmer health management of the symptoms associated with pesticide use

The great majority of farmers who noticed to experience symptoms during or right after pesticide use did not see a doctor or nurse or receive any check in a health care facility.

Table 6 health care of farmers experiencing potential symtoms of pesticide poisoning when using pesticides

Provinces	Não	Sim	null
Cabo Delgado	78.13%	1.56%	20.31%
Gaza	36.67%	0.00%	63.33%
Maputo	82.14%	3.57%	14.29%
Maputo Ciudade	45.00%	0.00%	55.00%
Nampula	85.00%	15.00%	0.00%
Niassa	83.33%	5.56%	11.11%
Tete	53.42%	0.00%	46.58%
Zambesia	91.18%	2.94%	5.88%
Grand Total	**67.38%**	**2.46%**	**30.15%**

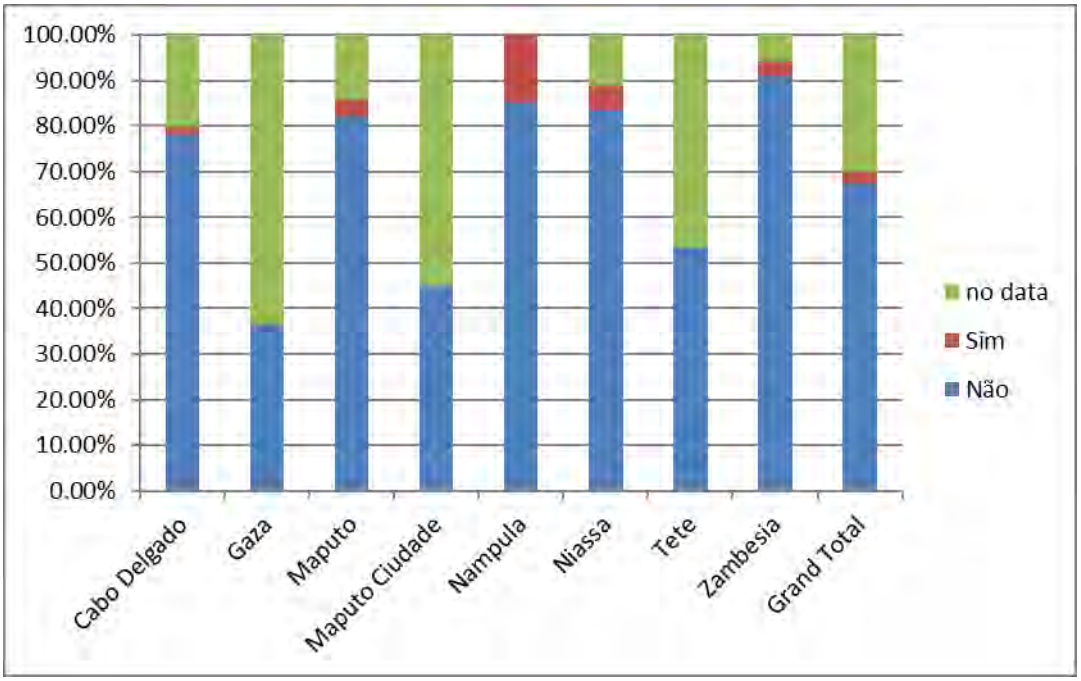


Figure 10 health care of farmers experiencing potential symtoms of pesticide poisoning when using pesticides

3.3.9. Use of Personal Protective Equipment by pesticide applicators including HHPs

Almost none of the farmers owned or wore adequate personal protective equipment. This is showns in the figures and tables below.

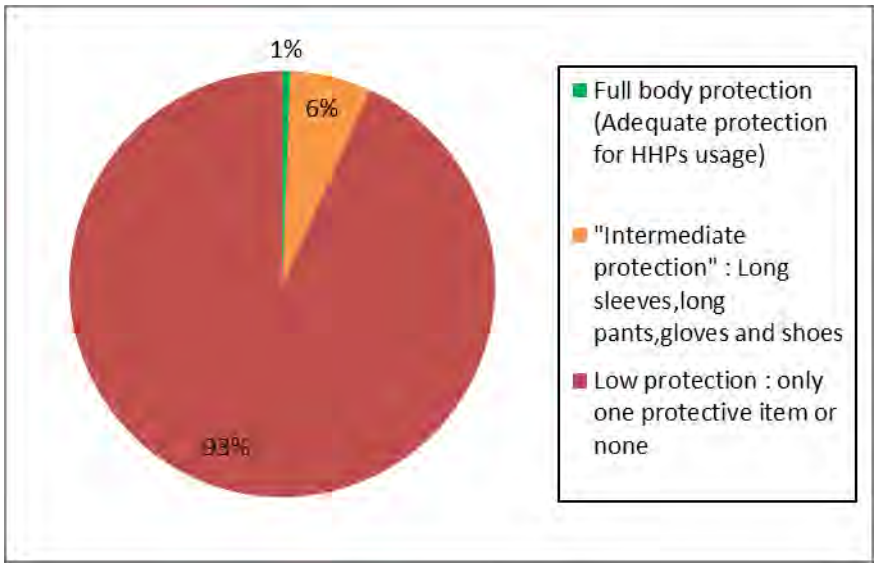


Figure 11 ***PPE usage for all farmers applying pesticides***

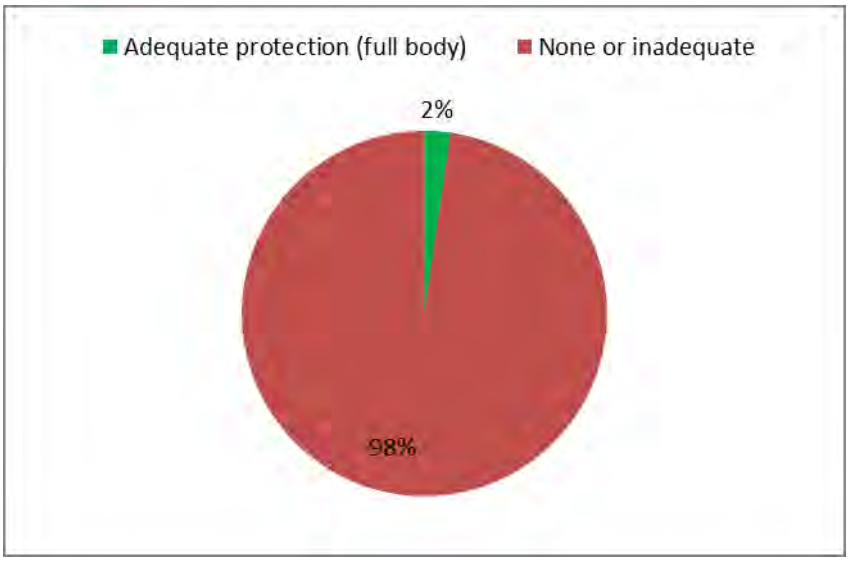


Figure 12 PPE usage for farmers applying HHPs

Table 7 Figure 14 clothes worn by pesticide applicators

Long pants	Shirt with long	Rubber boots	Gloves	bare feet or flip	T-shirt	Shorts	Shoes	Rubber mask	Overalls	Dust mask	Eyes glasses or	Other
63%	53%	39%	34%	34 %	29 %	17%	20%	15%	7%	3%	3%	2%

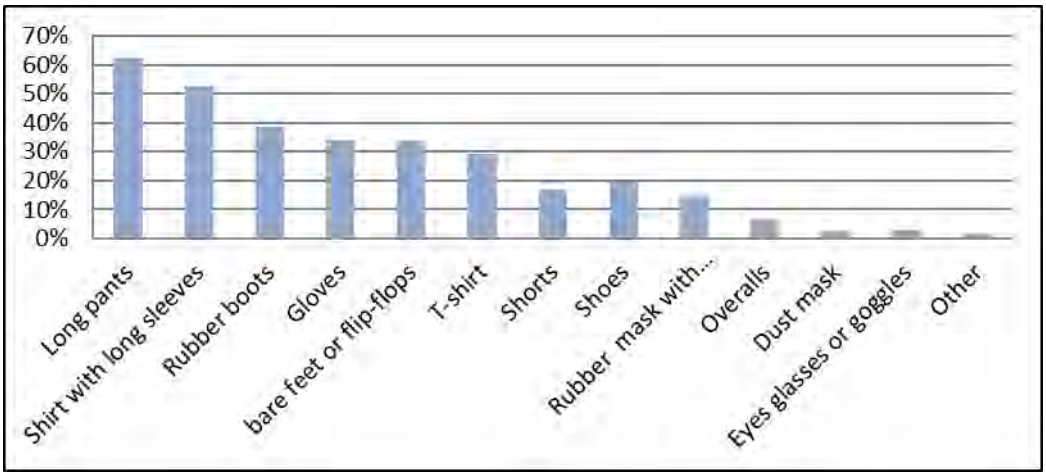


Figure 13 Clothes worn by pesticide applicators

3.3.10. Extent of protection of pesticide applicators by body part

Table 8 Protection used per body part by pesticide applicators

Row Labels	other	overalls	Rubber mask	Dust mask	no mask?	Eye glasses or	no eye	gloves	no gloves?	t-shirt	Shirt with	no shirt?	shorts	long pants	Rubber boots	Shoes	Bare feet
Grand Total	2	6	14	2	84	50	50	3	96	16	28	50	60	32	37	19	32

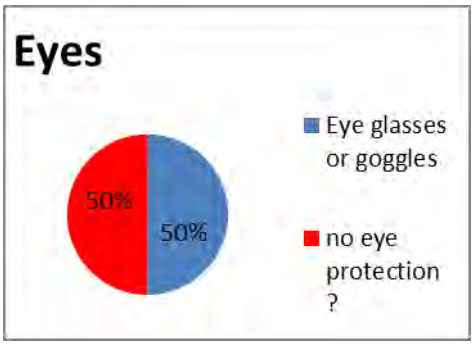


Figure 14 eye protection of pesticide applicators

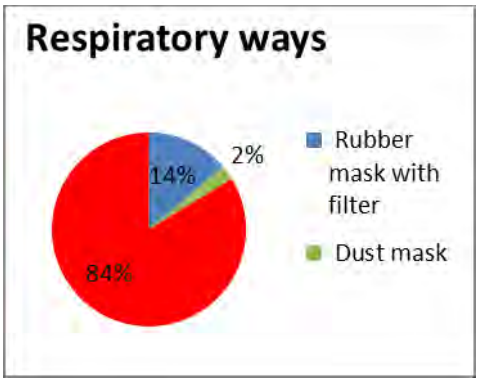


Figure 15 respiratory protection of pesticide applicators

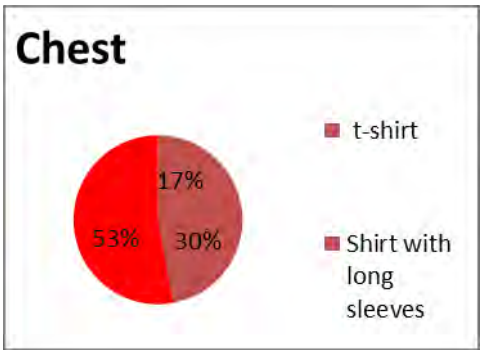


Figure 16 dermal chest protection of pesticide applicators

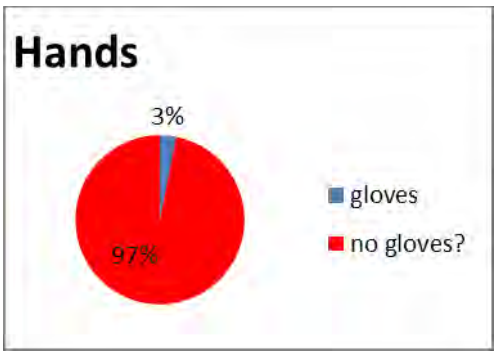


Figure 17 dermal hand protection of pesticide applicators

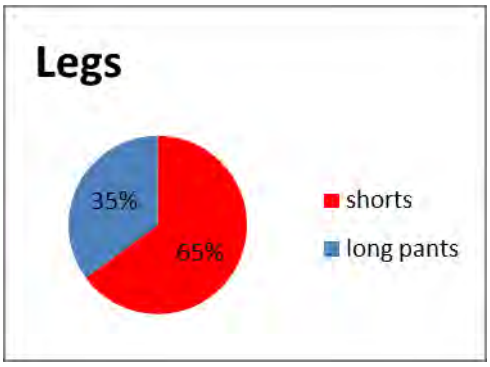


Figure 18 dermal leg protection of pesticide applicators

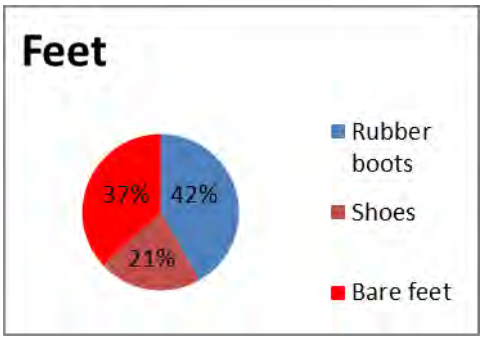


Figure 19 dermal feet protection of pesticide applicators

3.3.11. Pesticide label reading and understanding

Almost half of the farmers declared they did not read pesticide labels, includinguse instructions such as proper dosage and protective measures, the main reason being illiteracy. One out of four farmers poorly understood the colour band on pesticide labels that indicates acute toxicity. Tables and figures below show details by province and crops.

Table 9 percentage of farmers declaring to read the pesticide label per province

Provinces	Não	Sim	null	Grand Total (# of famers responding to this question	
Cabo Delgado	82.81%	10.94%	6.25%	64	
Gaza	86.67%	10.00%	3.33%	30	
Maputo	67.86%	32.14%	0.00%	28	
Maputo Ciudade	62.50%	37.50%	0.00%	40	
Nampula	95.00%	5.00%	0.00%	20	
Niassa	88.89%	5.56%	5.56%	36	
Tete	49.32%	46.58%	4.11%	73	
Zambesia	64.71%	35.29%	0.00%	34	
Grand Total	**71.38%**	**25.54%**	**3.08%**	**325**	

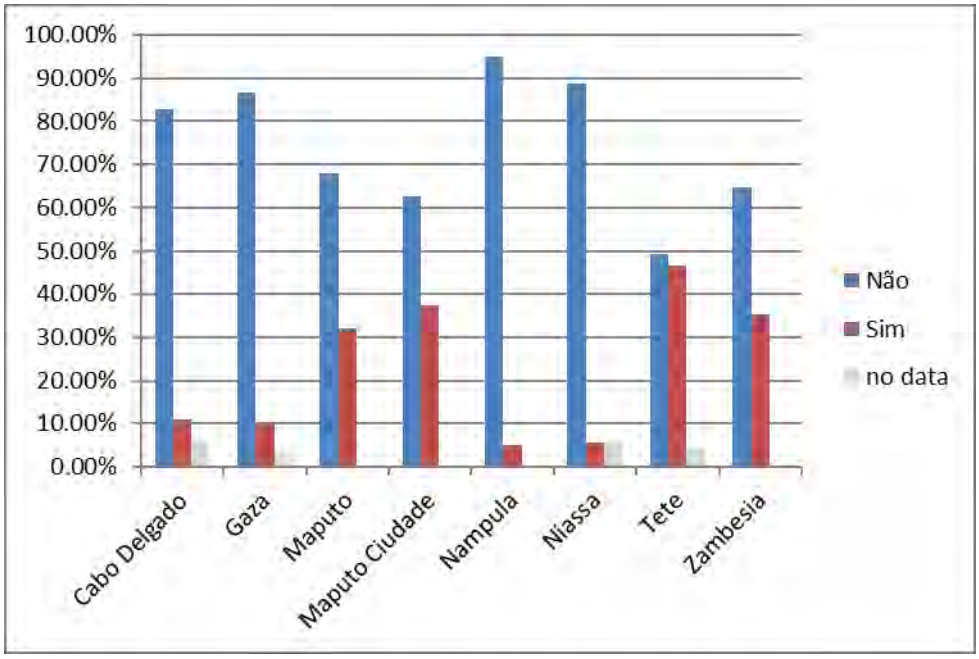


Figure 20 percentage of farmers declaring to read pesticide label per prvicince

Table 10 percentage of farmers declaring to read the label per crop and province

Row Labels	Não	Sim	null
Cotton	**41.48%**	**53.33%**	**5.19%**
Cabo Delgado	56.25%	37.50%	6.25%
Nampula	30.00%	70.00%	0.00%
Niassa	36.36%	45.45%	18.18%
Tete	28.00%	68.00%	4.00%
Zambesia	20.00%	80.00%	0.00%
Tobacco	**43.48%**	**55.43%**	**1.09%**
Niassa	56.00%	44.00%	0.00%
Tete	52.08%	45.83%	2.08%
Zambesia	5.26%	94.74%	0.00%
Vegetables, roots and tubers,pulses	**31.63%**	**66.33%**	**2.04%**
Gaza	20.00%	80.00%	0.00%
Maputo	21.43%	75.00%	3.57%
Maputo Ciudade	47.50%	50.00%	2.50%
Grand Total	**39.08%**	**57.85%**	**3.08%**

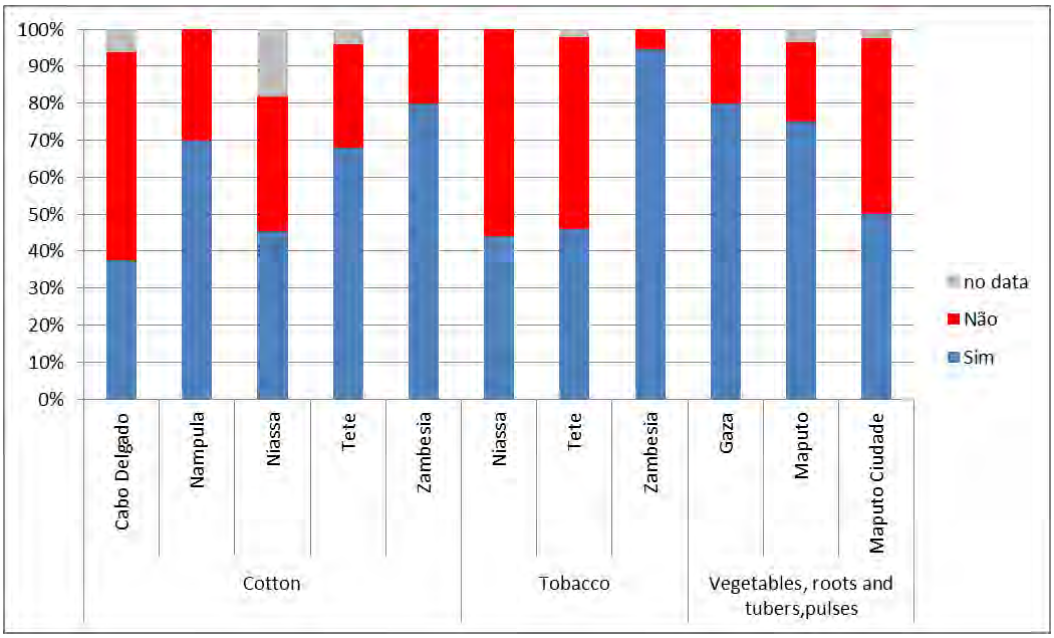


Figure 21 percentage of farmers read the label per province and crops

Table 11 farmers reporting to understand the pesticide label dosage

Row Labels	null	Não	Sim	Sim, com ajuda do técnico da empresa
Cabo Delgado	**6.25%**	**0.00%**	**93.75%**	**0.00%**
Cotton	6.25%	0.00%	93.75%	0.00%
Gaza	**0.00%**	**26.67%**	**73.33%**	**0.00%**
Vegetables, roots and tubers,pulses	0.00%	26.67%	73.33%	0.00%
Maputo	**7.14%**	**7.14%**	**85.71%**	**0.00%**
Vegetables, roots and tubers,pulses	7.14%	7.14%	85.71%	0.00%
Maputo Ciudade	**0.00%**	**37.50%**	**62.50%**	**0.00%**
Vegetables, roots and tubers,pulses	0.00%	37.50%	62.50%	0.00%
Nampula	**0.00%**	**85.00%**	**15.00%**	**0.00%**
Cotton	0.00%	85.00%	15.00%	0.00%
Niassa	**5.56%**	**83.33%**	**11.11%**	**0.00%**
Cotton	18.18%	72.73%	9.09%	0.00%
Tobacco	0.00%	88.00%	12.00%	0.00%
Tete	**2.74%**	**46.58%**	**50.68%**	**0.00%**
Cotton	4.00%	48.00%	48.00%	0.00%
Tobacco	2.08%	45.83%	52.08%	0.00%
Zambesia	**2.94%**	**5.88%**	**88.24%**	**2.94%**
Cotton	6.67%	13.33%	80.00%	0.00%
Tobacco	0.00%	0.00%	94.74%	5.26%
Grand Total	**3.38%**	**33.23%**	**63.08%**	**0.31%**

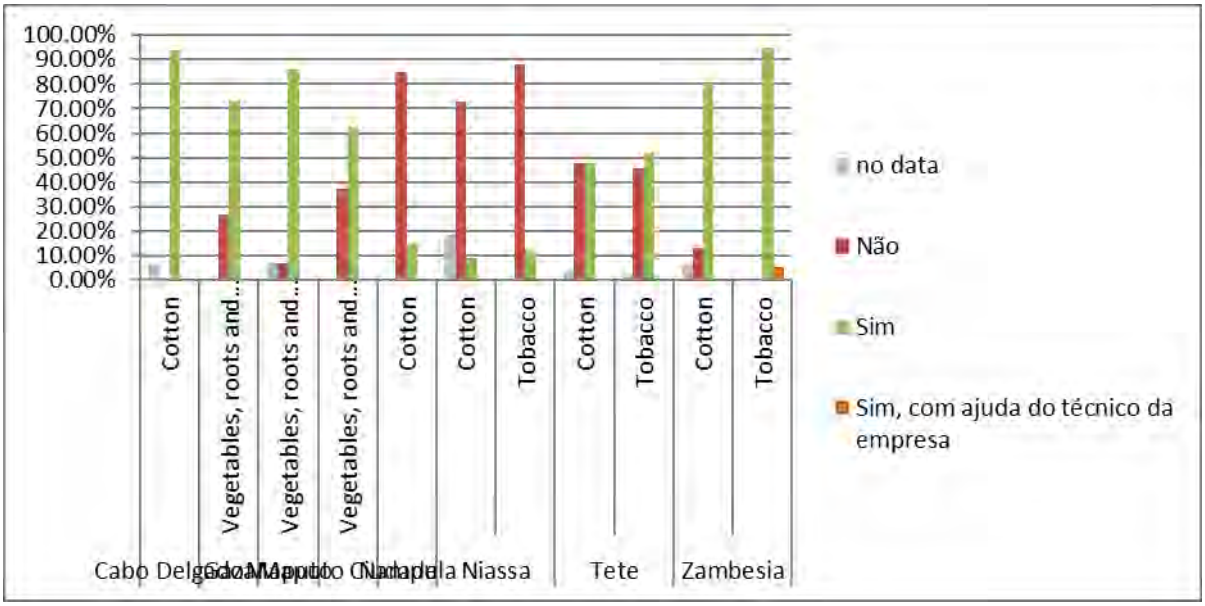


Figure 22 farmers reporting to understand the pesticide label dosage

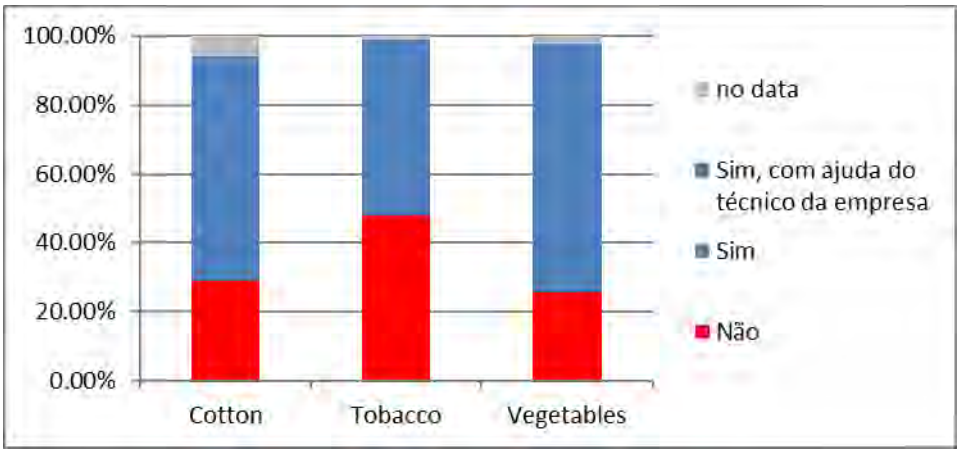


Figure 23 farmer reporting understanding the pesticide dosage instruction on the label per crop

3.3.4. Pesticide storage practices

About a third of farmers are storing pesticides inside their house

Provinces	Number of farmers storing the pesticide Inside the house	Number of farmers storing outside the house	Number of farmers
Cabo Delgado	33	21	60
Gaza	4	20	29
Maputo	1	25	28
Maputo Ciudade		38	38
Nampula	3	14	20
Niassa	16	16	34
Tete	50	15	70
Zambesia		33	34
Grand Total	**107**	**182**	**313**

Figure 24 pesticide storage practices per province

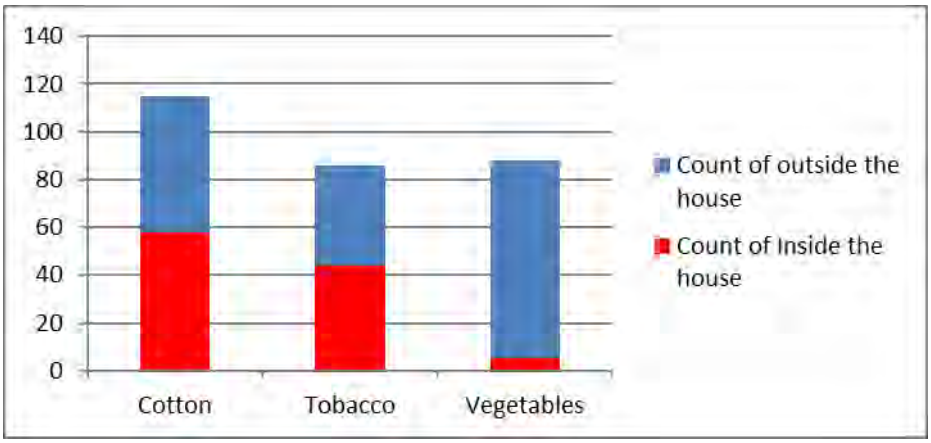


Figure 25 pesticide storage practices per crop

Preliminary discussion and conclusions

The survey results showed that the use of pesticides in general, and of HHPs in particular, was likely to result in undue exposure of farmers in the Mozambique.

Half of the farmers interviewed in the survey had not received any sort of training in using agrochemicals, and even those who had often lacked a good understanding of the risks involved through poor label reading and understanding and poor wearing of PPE. Many farmers in Mozambique do not have the required literacy and numeracy rate to even be able to understand the label. In addition PPE is often difficult to find, and expensive. As a result of all those reasons, the great majority of farmers survey (93%) did not wear appropriate protection to handle any HHPs and potentially neither a big share of the pesticides used.

For what concerns risk mitigation, it is difficult to enforce risk reduction measures that depend on wearing the appropriate PPE in these conditions. A further risk assessment is suggested by the survey and IPM programme targeting especially vegetables and cotton would improve the sustainability of the agricultural sector of Mozambique.

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Reducing Risks of Highly Hazardous Pesticides in Mozambique

Step 4 – Occupational risk assessments

Harold van der Valk

Armando Marcos W. Come

[7 May 2014]

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Acknowledgements

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Table of contents

1. Introduction

A project entitled *Reducing Risks of Highly Hazardous Pesticides (HHPs) in Mozambique* was initiated by the Government of Mozambique with the objective to reduce the greatest risks associated with pesticide use in the country. This project is implemented with technical support of FAO's Pesticides Management Unit and is funded by SAICM Quick Start Programme Trust Fund.

The ultimate goal is to develop and implement an "HHP Risk Reduction Action Plan" for the most dangerous pesticides and use situations, resulting over time in the implementation of a variety of risk reduction measures based on a review of use conditions. These may include the cancellation of specific registrations of HHPs, implementation of risk mitigation measures, appropriate use restrictions, development of alternative pest management strategies, promotion of good agricultural practices, or phase-out of specific pesticides.

In the first step of the project, a review of all pesticides registered in Mozambique was carried out and a shortlist of highly hazardous pesticides was established. This shortlist was based on an assessment of the hazards of the pesticides, based on criteria established by the FAO/WHO Joint Meeting on Pesticide Management (Come & Van der Valk, 2014).

During the second step of the project, a use survey was carried out in selected regions and cropping systems in Mozambique. The main goal of the survey was to identify the conditions under which pesticides are being used in the country and their contribution to potential risks for human health and the environment.

The third step of the project consisted of a stakeholder consultation to further discuss the use and risks of highly hazardous pesticides in Mozambique and fine-tune the shortlist based on the survey results and the expertise and experience of stakeholders.

Since the shortlist of HHPs was established based on hazard criteria only, potential exposure of pesticide users was not taken into account and an assessment of risks was not conducted. The study reported in the present document therefore attempts to quantify the occupational risk of selected HHPs, and some pesticides that have been classified as "coming close to "HHPs. The results of this risk assessment will be discussed against the hazard assessment conducted in step 1. The objective of the risk assessment is to assist the Government of Mozambique in taking informed decisions about measures that may need to be taken to reduce the risk of HHPs in the country.

2. Methodology

2.1 Principles of the risk assessment

The risk of occupational exposure to pesticides was assessed, in particular when spraying the products. The risk of worker exposure (e.g. during harvesting) or bystander exposure was not evaluated. For the occupational risk assessment an estimate of operator exposure was made, which was then compared to a toxicologically acceptable level.

Exposure of pesticide applicators was estimated using occupational exposure models that are often applied in the European Union: the so-called "German model" and the "UK Predictive Operator Exposure Model" (UK-POEM) (Hamey *et al*. 2008; EFSA 2010). The models are different in their exposure calculations and also include different exposure scenarios. Therefore, both models are often used in parallel in the EU when assessing occupational

exposure. Exposure scenarios and application parameters for the models were based on Mozambican pesticides application conditions.

An integral operator and worker exposure model ("EUROPOEM"), using more extensive databases, has been under development by the European Union for some time, but has not yet been formally adopted. It was therefore not used for this study. Similarly, in the US the Pesticide Handler Exposure Database (PHED) is being used for operator exposure estimation. However, this database has been under review for several years and alternative scenarios developed under the Agricultural Handler Exposure Task Force (AHETF) are not (yet) publicly available) (US-EPA, undated).

The toxicologically acceptable level of exposure applied in this study was the Acceptable Operator Exposure Level (AOEL), which is defined as the maximum amount of active substance to which the operator may be exposed without any adverse health effects (EC, 2006).

2.2 Pesticides and cropping systems

Pesticides that were short-listed as HHPs or "coming close" to HHPs in Step 1 of the project (Come & Van der Valk, 2014) were selected for the occupational risk assessment (Table 1).

Excluded from this assessment were aluminium phosphide which is used as a fumigant, chlorfenvinphos and formaldehyde registered as a veterinary pesticides, permetrhin for storage pest control, and the rodenticide difethialone, all for which no appropriate exposure models were available. Benomyl was also excluded as no recent appropriate AOEL was available.

Bendiocarb and DDT are being used for indoor residual spraying (IRS) against malaria mosquitoes. Although WHO (2011) developed risk assessment models for IRS, both for estimation of occupational and residential risks, these were not yet used in this study. Application of these models for the situation in Mozambique would require further discussions with the Ministry of Health to define the use conditions for IRS in the country.

The cropping systems that were evaluated are those for which the pesticide were registered. In some cases, crops were grouped together when the exposure to the pesticide were likely to be similar, based on height of the crop and the application method.

The volume application rates used in the model were generally those recommended on the label of the registered pesticide. If a volume application rate was not indicated on the label, 200 litres of pesticide mixture per ha was used as a default for EC or SC formulations applied with hydraulic nozzles or by air-assisted sprayers (high volume application). In the case of cotton applications, a scenario where 10 litres of mixture per ha was applied using rotary atomisers (low volume application) was also evaluated.

The dose rates used in the models were the highest rates recommended on the labels of the registered pesticide. In some cases where a wide range of dose rates was recommended, the lowest dose rate was also evaluated.

Table 1. Details on the pesticides and cropping systems used in the operator risk assessments

Pesticide	Concentration & type of formulation [1]	Cropping systems	Volume application rate (L mixture/ha)	Dose rate (L or kg formulation/ha	AOEL [2, 3] (mg a.i./kg bw/day)
Dichlorvos	1000 g a.i./L EC	Vegetables	200	0.2 & 1	0.0005 [A]
		Cotton	10	0.1	
		Cotton, flowers, ornamentals	200	0.2	
	100 g a.i./L EC	Vegetables	200	0.2	
Endosulfan	350 g a.i./L EC	Cotton	200	2	0.0042 [B]
			10	2	
		Vegetables	200	2	
		Maize, sorghum	200	1.2	
		Ornamentals	200	0.5	
Methamidophos	585 g a.i./L SL	Vegetables	200	1	0.00006 [C]
		Cotton, tobacco	10	1.7	
			200	1.7	
Oxamyl	310 g a.i./L SL	Sugar cane	300	9.6	0.01[A]
		Tobacco	300	2.4	
		Pineapple, potato, tomato	300	2.4	
2,4-D dimethylamine	720 g a.i./L SL	Palm tree, cocoa, coconut	200	3	0.15 [A]
		Cabbage, rice	200	3	
Paraquat	200 g.a.i./L SL	Sugar cane	200	3	0.0004 [A]
		Bananas	200	5	
		Vegetables	200	2.5	
Diuron	800 g a.i./kg WP	Sugar cane	200	4.5	0.007 [A]
	800 g a.i./kg WG	Sugar cane	200	4.5	
	800 g a.i./L SC	Sugar cane	200	4.5	
		Fruit & nut trees	200	4	
Mancozeb	800 g a.i./kg WP	Vegetables	200	1	0.035 [A]
				4	
		Fruit trees	200	1.8	
				5.2	
Oxyfluorfen	240 g a.i./L EC	Vegetables, soybean	350	3	0.013 [A]
		Pine & eucalyptus trees, citrus			
		Cotton			

[1] a.i. = active ingredient; WP = wettable powder; SL = soluble concentrate; WG -= wettable granules

[2] bw = bodyweight

[3] Sources of AOELs: [A] = FootPrint – Pesticide Properties Database (undated); [B] = Rotterdam Convention (2011); [C] = ERMA (2010)

2.3 Acceptable Operator Exposure Levels

The Acceptable Operator Exposure Level (AOEL) was used in the risk assessment as the toxicologically acceptable level of exposure of a pesticide operator. No fundamental difference in sensitivity to pesticides was assumed to exist between a pesticide applicator in Mozambique and one in Europe or elsewhere. Therefore, AOELs as officially established by reputable regulatory authorities in other parts of the world were used. In most cases, the European Union AOELs were applied, as listed in the FootPrint Pesticide Properties Database (PPDB, undated). In the few cases when no EU values were available, other sources were used, such as the Environmental Risk Management Authority of New Zealand (ERMA, 2010) or the Rotterdam Convention Decision Guidance Documents (Table 1).

2.4 Operator exposure models

The specifics of the German and the UK POEM models have been summarized by Hamey *et al.* (2008) and Busschers (2012). Only a summary of the key parameters is provided below.

The German Model provides operator exposure scenarios for vehicle-mounted pesticide application equipment with hydraulic nozzles (downwards) and for air-assisted spraying (upwards) and for handheld application equipment (low-level and high-level targets). Pesticide formulations included are wettable powders (WP), wettable granules (WG) and liquid formulations. Various options for personal protective equipment can be chosen. The option for "No PPE" represents a moderately dressed operator with shoes and socks, and half of the upper arms, forearms, thighs and lower legs unprotected.

The UK POEM provides operator exposure scenarios for vehicle-mounted pesticide application equipment with hydraulic nozzles (downwards), rotary atoimisers (upwards) and for air-assisted spraying (upwards). Handheld application equipment is modeled for hydraulic nozzles (downward spraying) and rotary atomisers (upwards and downwards), as well as a home/garden sprayer (downwards). Pesticide formulations included are wettable powders (WP), wettable granules (WG), water soluble bags (WB) and liquid formulations (both water-based and organic solvents). Various options for personal protective equipment can be chosen. The option for "No PPE" represents a single layer of work clothing for professional use, or a T-shirt and shorts for home garden use.

The versions of the models used for this study are the German Model PSD1 and the UK POEM 07, both available at the UK CRD web site[1].

2.5 Pesticide application scenarios

The most common pesticide application practices in Mozambique were identified for each of the evaluated cropping systems. The pesticide application scenarios available in the two operator exposure models that came closest to Mozambican practices were then chosen for the calculations. The models were run both assuming complete personal protective equipment (PPE) likely to be worn in Mozambique, as well as using "no PPE" (see chapter 2.4, for the definitions of no PPE in the models). In this way both good personal protection practices and limited personal protection were simulated.

The evaluated pesticide application scenarios are summarized in Table 2.

[1] http://www.pesticides.gov.uk/guidance/industries/pesticides/topics/pesticide-approvals/pesticides-registration/applicant-guide/the-applicant-guide-completing-an-application-overview-for-operator-and-consumer-exposure.htm

Table 2. Details on the pesticide application scenarios used in the operator risk assessments

Cropping system	Model	Application method	Work rate per day; duration of spraying	Size & type of container [1]	PPE	
					Mixing/ loading	Spraying
Vegetables, rice	UK-POEM	hand-held sprayer; low level target	1 ha; 6 hours	1 L; any closure	none or gloves	none or gloves & coveralls
	UK-POEM	home/garden; low level target	0.1 ha; 0.5 hours	1 L; any closure	none	none
Pineapple, potato, tomato	UK-POEM	hand-held sprayer; low level target	1 ha; 6 hours	5 L; 45 or 63 mm closure	none or gloves	none or gloves & coveralls
Cotton, tobacco	UK-POEM	hand-held rotary atomiser; high level target	2 ha; 4 hours	1 L; any closure	none or gloves	none or gloves & coveralls
	German	hand-held sprayer; high level target	2 ha	--	none or P2 mask & gloves	none or coveralls & hat & gloves & P2 mask
Cotton, tobacco (herbicides)	UK-POEM	hand-held rotary atomiser; high level target	2 ha; 4 hours	1 L; any closure	none or gloves	none or gloves & coveralls
Maize, sorghum, flowers, ornamentals	German	hand-held sprayer; high level target	2 ha	--	none or P2 mask & gloves	none or coveralls & hat & gloves & P2 mask
Sugar cane, Bananas	UK-POEM	hand-held sprayer; low level target	1 ha; 6 hours	5 L; 45 or 63 mm closure	none or gloves	none or gloves & coveralls
	UK-POEM	Tractor-mounted sprayer; hydraulic nozzles	15 ha; 6 hours	20 L; 63 mm closure	none or gloves	none or gloves
Plantation crops, Fruit & nut trees (herbicides)	UK-POEM	hand-held sprayer; low level target	1 ha; 6 hours	5 L; 45 or 63 mm closure	none or gloves	none or gloves & coveralls
Fruit trees	UK-POEM	Tractor mounted sprayer; air assisted	15 ha; 6 hours	20 L; 63 mm closure	none or gloves	none or gloves
	German	Tractor mounted sprayer; air assisted	15 ha	--	none or P2 mask & gloves	none or coveralls & hat & gloves & P2 mask
	German	hand-held sprayer; high level target	2 ha	--	none or P2 mask & gloves	none or coveralls & hat & gloves & P2 mask

[1] only for liquid formulations in UK POEM

3. Results

3.1 Expression of risk

The risk for the pesticide operator has been expressed as a risk quotient, which is the ratio between the estimated exposure of the operator to the pesticide (in mg a.i./kg bw/day) and the AOEL (in mg a.i./kg bw/day). A risk quotient > 1 implies that the risk is not acceptable; a risk quotient ≤ 1 implies an acceptable risk. For instance, a risk quotient of 100 means that the estimated exposure level of the operator, for the given pesticide application scenario, is a 100 times higher than the acceptable exposure level.

The results of the pesticide operator risk assessments are summarized in the tables below. Risk quotients are given for the scenario when no PPE is worn during both mixing and spraying (worst case situation) and for the scenario with full PPE during both mixing and spraying (best practice situation).

3.2 Outcome of the risk assessments

Table 3 shows the results for the application of the insecticide **dichlorvos** in vegetables and cotton, ornamentals and flowers. The latter three crops were grouped as crop structure and the application scenarios are relatively similar.

The dichlorvos 1000 g/L EC formulation, when applied in vegetables at 200 g a.i./ha, resulted in unacceptable risk to the operator, both when applied professionally (with or without PPE) and when applied in small volumes simulating home/garden use. In the latter scenario no PPE is being used. The use of the lower concentration formulation of dichlorvos at 100 g/L EC, which is not strictly a HHP, also resulted in operator exposure exceeding the acceptable level by a factor 11 when PPE was used. The application rate of 200 g a.i./ha is the lowest registered in Mozambique in vegetables; the highest registered rate of 1000 g a.i./ha, would result in an even larger exceedance of the AOEL.

The lowest registered application rate of dichlorvos in cotton, ornamentals and flowers is 100 g a.i/ha. This resulted in unacceptable risk for the operator in all scenarios, both with and without PPE. In particular application with rotary atomisers showed a large exceedance of the AOEL. The highest registered rate, of 200 g a.i./ha was not further not assessed, since it would lead to even higher exceedance of the AOEL.

Table 3. Outcome of the operator risk assessments for the highly hazardous pesticide (HHP) formulation containing dichlorvos

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
1000 g/L EC	Vegetables	200 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	811
				Mixing yes; spraying yes	113
			UK – home/garden; low level target	Mixing no; spraying no	188
	Cotton, ornamentals, flowers	100 g a.i./ha	UK – hand-held rotary atomiser; high level target	Mixing no; spraying no	1930
				Mixing yes; spraying yes	406
			German – hand-held sprayer; high level target	Mixing no; spraying no	284
				Mixing yes; spraying yes	13
100 g/L EC *	Vegetables	200 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	81
				Mixing yes; spraying yes	11
			UK – home/ garden; low level target	Mixing no; spraying no	19
124 g/L AE *	Aerosol		No risk assessment model		--

* Formulation of dichlorvos identified as "coming close to HHP"

Table 4 shows the results for the application of the insecticide **endosulfan** in vegetables, cotton, maize and sorghum, and ornamentals and flowers. All scenarios in vegetables, cotton, and maize and sorghum resulted in operator exposure exceeding acceptable levels. Only the application of endosulfan at 175 g a.i./ha in ornamentals and flowers resulted in almost acceptable exposure levels when full protective equipment was being worn.

Table 4. Outcome of the operator risk assessments for the highly hazardous pesticide (HHP) formulation containing endosulfan

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
350 g/L EC	Vegetables	700 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	164
				Mixing yes; spraying yes	30
			UK – home/ garden; low level target	Mixing no; spraying no	28
	Cotton	700 g a.i./ha	UK – hand-held rotary atomiser; high level target	Mixing no; spraying no	1397
				Mixing yes; spraying yes	318
			German – hand-held sprayer; high level target	Mixing no; spraying no	119
				Mixing yes; spraying yes	4.3
	Maize & sorghum	420 g a.i./ha	German – hand-held sprayer; high level target	Mixing no; spraying no	71
				Mixing yes; spraying yes	2.6
	Ornamentals & flowers	175 g a.i./ha	German – hand-held sprayer; high level target	Mixing no; spraying no	30
				Mixing yes; spraying yes	1.1

Table 5 shows the results for the application of the insecticide **methamidophos** in vegetables, cotton, and tobacco. Acceptable operator exposure levels are greatly exceeded in all models and scenarios, indicating a very high risk of applying methamidophos even when PPE is being used.

Table 5. Outcome of the operator risk assessments for the highly hazardous pesticide (HHP) formulation containing methamidophos

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
585 g/L SL	Vegetables	585 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	10667
				Mixing yes; spraying yes	1733
			UK – home/ garden; low level target	Mixing no; spraying no	1967
	Cotton Tobacco	995 g a.i./ha	UK – hand-held rotary atomiser; high level target	Mixing no; spraying no	139150
				Mixing yes; spraying yes	31550
			German – hand-held sprayer; high level target	Mixing no; spraying no	11783
				Mixing yes; spraying yes	267

Table 6 shows the results for the application of the insecticide **oxamyl** in sugar cane, tobacoo, and pineapple, potato and tomato. The latter three crops were grouped together as crop structure and the application scenarios were relatively similar.

For all crops and application scenarios was the acceptable exposure level exceeded, with risk quotients of about 10 or more even when PPE was being used. Only in tobacco, at the lowest dose rate and when using full PPE, did the risk quotient approach one.

Table 6. Outcome of the operator risk assessments for the highly hazardous pesticide (HHP) formulation containing oxamyl.

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
310 g/L SL	Sugar cane	2976 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	181
				Mixing yes; spraying yes	34
			UK – tractor-mounted boom sprayer; hydraulic nozzles	Mixing no; spraying no	132
				Mixing yes; spraying yes	15
	Pineapple Potato Tomato	744 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	53
				Mixing yes; spraying yes	9
	Tobacco	744 g a.i./ha	German – hand-held sprayer; high level target	Mixing no; spraying no	53
				Mixing yes; spraying yes	1.2

Table 7 shows the results for the application of the herbicide **paraquat** in sugar cane, bananas and vegetables.

Paraquat was identified a pesticide "coming close to a HHP" by Come and Van der Valk (2013). The occupational risk assessments that were conducted showed that acceptable operator exposure levels were greatly exceeded for all crops and all pesticide application scenarios, irrespective of the application rate or use of PPE. This indicates that the application of paraquat likely poses a high risk under Mozambican use conditions.

Table 7. Outcome of the operator risk assessments for formulations containing paraquat, a pesticide "coming close to a HHP"

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
200 g/L SL	Sugar cane	600 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	1408
				Mixing yes; spraying yes	255
			UK – tractor-mounted boom sprayer; hydraulic nozzles	Mixing no; spraying no	653
				Mixing yes; spraying yes	95
	Bananas	1000 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	2268
				Mixing yes; spraying yes	423
			UK – tractor-mounted boom sprayer; hydraulic nozzles	Mixing no; spraying no	1045
				Mixing yes; spraying yes	155
	Vegetables	500 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	1193
				Mixing yes; spraying yes	213
			UK – home/ garden; low level target	Mixing no; spraying no	203

Table 8 shows the results for the application of the herbicide **2,4-D dimethylamine** in palm trees, cocoa and coconut, and in cabbage and rice. Crops were grouped together as crop structure and the application scenarios were considered similar.

2,4-D dimethylamine was identified a pesticide "coming close to a HHP" by Come and Van der Valk (2013). The occupational risk assessments that were conducted showed that acceptable operator exposure levels were exceeded for all crops and all pesticide application scenarios. In the cases when PPE was used, or when applying the herbicide in the home/garden scenario, limited exceedance of the AOEL was estimated, of about a factor 2.5.

Table 8. Outcome of the operator risk assessments for formulations containing 2,4-D dimethylamine, a pesticide "coming close to a HHP".

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
720 g/L SL	Palm tree Cocoa Coconut	2160 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	14
				Mixing yes; spraying yes	2.5
	Cabbage Rice	2160 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	14
				Mixing yes; spraying yes	2.4
			UK – home/ garden; low level target	Mixing no; spraying no	2.3

Table 9 shows the results for the application of the fungicide **mancozeb** in vegetables and in fruit trees and bananas. Since the registered dose rates for this pesticide varied widely, both the highest and the lowest registered rates were assessed.

Mancozeb applied in vegetables at 3200 g a.i./ha resulted in unacceptable operator exposure, irrespective of the use of PPE. However, when applied at 800 g a.i./ha, operator exposure was acceptable if PPE was worn or for the home/garden scenario (i.e. only 0.5 hours spraying per day on 0.1 ha). In case no PPE was used, the AOEL was also exceeded at this lowest registered application rate.

In fruit trees and bananas, the operator exposure exceeded the acceptable level for all scenarios when mancozeb was applied at the high rate of 4200 g a.i./ha. Only in the case of hand-held sprayers and wearing full PPE did the risk quotient approach one. The same scenario resulted in acceptable operator exposure at the lowest dose rate of 1440 g a.i./ha. All other scenarios at the lowest dose rate yielded risk quotients exceeding one, indicating unacceptable risk.

Table 9. Outcome of the operator risk assessments for formulations containing mancozeb, a pesticide "coming close to a HHP".

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
800 g/kg WP	Vegetables	3200 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	13.4
				Mixing yes; spraying yes	2.6
			UK – home/ garden; low level target	Mixing no; spraying no	1.8
		800 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	3.4
				Mixing yes; spraying yes	0.66
			UK – home/ garden; low level target	Mixing no; spraying no	0.46
	Fruit trees Bananas	4200 g a.i./ha	German – hand-held sprayer; high level target	Mixing no; spraying no	34
				Mixing yes; spraying yes	1.5
			German – tractor-mounted; air-assisted sprayer	Mixing no; spraying no	156
				Mixing yes; spraying yes	9.1
			UK – tractor-mounted; air-assisted sprayer	Mixing no; spraying no	20
				Mixing yes; spraying yes	8.3
		1440 g a.i./ha	German – hand-held sprayer; high level target	Mixing no; spraying no	11.9
				Mixing yes; spraying yes	0.51
			German – tractor-mounted; air-assisted sprayer	Mixing no; spraying no	54
				Mixing yes; spraying yes	3.1
			UK – tractor-mounted; air-assisted sprayer	Mixing no; spraying no	7.0
				Mixing yes; spraying yes	2.9

Table 10 shows the results for the application of the herbicide **diuron** in sugar cane and in various fruit and nut trees. The latter were grouped together because crop structure and the application scenarios were similar.

Various formulation of diuron and application scenarios were modelled in sugar cane. In all cases was the AOEL exceeded, irrespective of the use of PPE. Operator exposure in fruit trees was also unacceptable, in spite of the lower dose rate of diuron being registered.

Table 10. Outcome of the operator risk assessments for formulations containing diuron, a pesticide "coming close to a HHP".

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
800 g/kg WP	Sugar cane	3600 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	77
				Mixing yes; spraying yes	15
800 g/kg WG	Sugar cane	3600 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	64
				Mixing yes; spraying yes	13
800 g/L SC	Sugar cane	3600 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	546
				Mixing yes; spraying yes	87
800 g/kg WP	Sugar cane	3600 g a.i./ha	UK – tractor-mounted boom sprayer; hydraulic nozzles	Mixing no; spraying no	65
				Mixing yes; spraying yes	8.1
800 g/L SC	Sugar cane	3600 g a.i./ha	UK – tractor-mounted boom sprayer; hydraulic nozzles	Mixing no; spraying no	207
				Mixing yes; spraying yes	32
800 g/L SC	Citrus Avocado Banana Mango Macadamia nuts	3200 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	420
				Mixing yes; spraying yes	77

Table 10 shows the results for the application of the herbicide **oxyfluorfen** in vegetables, soybean, cotton and in citrus and forestry uses. In all cases was the AOEL exceeded, irrespective of the use of PPE.

Table 11. Outcome of the operator risk assessments for formulations containing oxyfluorfen, a pesticide "coming close to a HHP".

Pesticide formulation	Cropping system	Application rate	Exposure model	Use of PPE	Risk quotient
240 g/L EC	Vegetables, soybean	720 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	35
				Mixing yes; spraying yes	5.6
240 g/L EC	Cotton	432 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	33
				Mixing yes; spraying yes	5.8
240 g/L EC	Citrus Pine trees Eucalyptus trees	720 g a.i./ha	UK – hand-held sprayer; low level target	Mixing no; spraying no	30
				Mixing yes; spraying yes	4.2

4. Discussion and conclusions

4.1 Methodology

The models used in this occupational risk assessment are commonly applied for first tier (conservative) risk assessment in the European Union. They generate exposure estimates based on databases containing the results of occupational exposure studies submitted for registration or of independently published scientific studies (Hamey *et al.*, 2008). The majority of these studies have been conducted in Europe and reflect pesticide application practices in this region. Pesticide application practices in Mozambique can be expected to be less precise because of the more limited training of operators. Pesticide application equipment in Mozambique also may be of lower quality and will generally be less well maintained. For these reasons, occupational exposure to pesticides under Mozambican conditions will likely be higher than similar application scenarios included in the databases of the UK and German models.

The pesticide dose rates used for the occupational risk assessment were those registered in Mozambique. When only maximum registered rates were used, this may lead to an overestimate of exposure. In cases when also the minimum rate was included in the assessment, when a wide range of rates was registered, this bias will not have occurred. No actual application rates, as used by farmers, were used for the assessments. It is not known whether farmers systematically underdose or overdose in Mozambique, and therefore there is no indication of possible bias of the exposure models.

The use of personal protective equipment was taken into account in the risk assessments, both during mixing of the spray solution and loading of the sprayer (Table 2). The no-PPE option in the German model represents an operator with shoes and socks, and half of the upper arms, forearms, thighs and lower legs unprotected. In the UK model, the no-PPE option represents a single layer of work clothing for professional use, or a T-shirt and shorts for home garden use. In Mozambique, pesticide application without PPE generally means that the operator wears shorts, a short-sleeved T-shirt or a tank top, and open sandals. Therefore, the no-PPE option in both models likely underestimates actual exposure under Mozambican conditions.

Overall, the risk of exposure in Mozambique is likely to be higher than what would be the case in Europe, and might even be higher than the conservative exposure estimates generated by the two models used here.

4.2 Risk mitigation

When model estimates of occupational exposure exceed the acceptable operator exposure level, either the risk assessment can be refined or risk mitigation measures can be taken.

Refinement of the risk assessment may be possible by using the results of real exposure measurements, conducted under locally relevant field conditions. These can be the outcome of occupational exposure experiments or data from exposure monitoring following operational pesticide application.

Various risk mitigation measures can, in principle, also be taken. If exceedance is relatively limited, it may be possible to reduce dose rates without efficacy being jeopardised. This will normally not be feasible to any large extend since the registered dose rate should be the lowest effective rate against the pest that needs to be controlled.

If exceedance of the AOEL only occurs in the no-PPE scenario, but with PPE the risk is acceptable, using appropriate PPE can part of the registration requirements. Requiring (more protective) PPE tends to be the risk mitigation measure of choice in Europe and the USA.

Under Mozambican conditions, such a requirement likely means that the pesticide will have to be restricted to use by professional applicators only, because the use of PPE by small farmers cannot effectively be enforced.

If exceedance of the AOEL only occurs for specific cropping systems or application methods, pesticide registration can be refused for these specific situations, but granted for crops or applications methods leading to acceptable exposure. In some cases, engineering measures, such as using a closed, ventilated, cab on a tractor, may reduce operator exposure. Other engineering controls which may reduce occupational exposure include closed pesticide transfer systems, low-drift nozzles, integrated tank rinsing systems or direct pesticide injection systems. In some cases it may be possible to change to a less hazardous pesticide formulation, e.g. water dispersible granules rather than wettable powders. However, many such engineering control may not be economically feasible on a large scale in Mozambique.

Finally, if no risk mitigation measures can be taken that are realistic under the Mozambican conditions of use of the pesticide, its registration should be refused (for a new application) or cancelled (for an existing one).

4.3 Occupational risks

The occupational risk assessments showed that the applications of six pesticides at registered dose rates would result in exceedance of acceptable operator exposure levels in all cropping systems that were assessed, both with and without PPE. These were **dichlorvos, methamidophos, 2,4-D dimethylamine, paraquat, diuron and oxyfluorfen** (Table 12).

Given the large risk quotient, it is unlikely that locally feasible mitigation measures would reduce the risk of dichlorvos, methamidophos and paraquat to acceptable levels.

The occupational risk of diuron in sugar cane and plantation crops might be reduced by using closed ventilated cabins on tractors in sugar cane.

The exceedance of the AOEL when applying 2,4-D dimethylamine and oxyfluorfen with PPE was relatively limited (RQ = 2.3 – 5.8). Possibly the strict enforcement of using full PPE combined with engineering control such as low-drift nozzles could reduce the occupational risk to acceptable levels.

Applications of endosulfan exceeded acceptable operator exposure levels for all crops except one. Only in the case of ornamentals and flowers, when protective equipment is used, was the Risk quotient 1.1; i.e. approaching acceptability.

Similarly, the use of oxamyl resulted in unacceptable operator exposure in all crops except tobacco. If full PPE was used in tobacco, the risk quotient approached acceptability (RQ = 1.2).

Mancozeb applied in vegetables at the lowest registered dose rate of 800 g a.i./ha led to acceptable operator exposure when PPE was worn or in the case of home/garden applications (i.e. small plots and short spraying time). On commercial plots and with no PPE, exposure exceeded the AOEL. This was also the case for all uses with the high application rate.

Table 12. Summary of the results of the operator risk assessments.

Pesticide	Formulation [type] (g a.i./L)	Evaluated crops	Evaluated application rates (g a.i./ha)	Exceedance of AOEL	
				With PPE	Without PPE
Dichlorvos	1000 [EC]	Vegetables, cotton, flowers, ornamentals	≥ 100	All cases	All cases
	100 [EC]	Vegetables	20	All cases	All cases
Methamidophos	585 [SL]	Vegetables, cotton, tobacco	≥ 585	All cases	All cases
2,4-D dimethylamine	720 [SL]	Palm tree, cocoa, coconut, cabbage, rice	2160	All cases	All cases
Paraquat	200 [SL]	Sugar cane, bananas, vegetables	≥ 500	All cases	All cases
Diuron	800 [WP/WG/SC]	Sugar cane, fruit & nut trees	≥ 3200	All cases	All cases
Endosulfsan	350 [EC]	Cotton, vegetables, maize, sorghum	≥ 420	All cases	All cases
		Ornamentals & flowers	175	Close to no exceedance	All cases
Oxamyl	310 [SL]	Sugar cane, pineapple, potato, tomato	≥ 744	All cases	All cases
		Tobacco	744	Close to no exceedance	All cases
Mancozeb	800 [WP]	Vegetables	3200	All cases	All cases
			800	No exceedance	No exceedance for home/ garden use
		Fruit trees, bananas	4200	All cases	All cases
			1440	No exceedance for held-held sprayers	All cases
Oxyfluorfen	240 [EC]	Vegetables, soybean, trees	720	All cases	All cases
		Cotton	432	All cases	All cases

4.3 Conclusion

The occupational risk assessments reported in this study largely confirm that the majority of pesticide products identified as highly hazardous pesticides on the basis of hazard criteria would also lead to unacceptable occupational exposure on the basis of risk assessment.

Eight out of the nine pesticides showed exceedance of the acceptable operator exposure levels with or without the use of PPE. Only two of these seven (endosulfan and oxamyl) came closer to no exceedance of the AOEL at the lowest registered dose rates, with PPE and for specific

application methods. All other showed factors of exceeding the AOEL ranging from about 10x to more than 100000x

The use of mancozeb, a pesticide identified as “coming close to HHP”, did not result in exceedance of the AOEL at the lowest registered dose rates and if PPE was used. Without PPE, only the use of mancozeb in vegetables when modelled as “home/garden use” led to exposure below acceptable levels. It may be questioned, however, whether the “home/garden use” model (i.e. plot size 0.1 ha and maximum 0.5 hours pesticide spraying per day) properly represents Mozambican small scale vegetable farming.

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REPORT

2ND FAO/WHO JOINT MEETING ON PESTICIDE MANAGEMENT

and

4TH SESSION OF THE FAO PANEL OF EXPERTS ON PESTICIDE MANAGEMENT

6 – 8 October 2008
Geneva

Food and Agriculture Organization of the United Nations

World Health Organization

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Abbreviations

ADI	Acceptable Daily Intake
ASP	Africa Stockpiles Programme
CCPR	Codex Committee on Pesticide Residues
CIEN	Chemicals Information Exchange Network
CMR	Carcinogenic, Mutagenic and Reproductive toxicant
FAO	Food and Agriculture Organization of the United Nations
GCDPP	Global Collaboration for Development of Pesticides for Public Health
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
GLP	Good Laboratory Practice
GMP	Global malaria Programme
HHP	Highly Hazardous Pesticide
HQ	Headquarters
IARC	International Agency for Research on Cancer
ICC	International Chamber of Commerce
ICCM	International Conference on Chemicals Management
ICSC	International Chemical Safety Card
IFCS	Inter-governmental Forum on Chemical Safety
IGO	Inter-governmental Organization
IOMC	Inter-Organization Programme for the Sound Management of Chemicals
IPCS	International Programme on Chemical Safety
IPM	Integrated Pest Management
IVM	Integrated Vector Management
JMPR	Joint Meeting on Pesticide Residues
JMPS	Joint Meeting on Pesticide Specifications
MEA	Multilateral Environmental Agreement
MRL	Maximum Residue Limit
NGO	Non-governmental Organization
OECD	Organization for Economic Co-Operation and Development
PAN	Pesticide Action Network
PIC	Prior Informed Consent
PIM	Poisons Information Monograph
POP	Persistent Organic Pollutant
SAICM	Strategic Approach to International Chemicals Management
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNITAR	United Nations Institute for Training and Research
WHO	World Health Organization
WHOPES	World Health Organization Pesticide Evaluation System

1. Introduction

The 2nd FAO/WHO Joint Meeting on Pesticide Management and 4th Session of the FAO Panel of Experts on Pesticide Management, were held at WHO Headquarters in Geneva from 6 to 8 October 2008.

The FAO Panel of Experts on Pesticide Management is the official statutory body that advises the Organization on matters pertaining to pesticide regulation and management, and alerts it to new developments, problems or issues that otherwise merit attention. The Panel in particular counsels FAO on the further implementation of the revised version of the *International Code of Conduct on the Distribution and Use of Pesticides*[1] (the Code of Conduct). Members of the WHO Panel of Experts are drawn from the WHO Panel of Experts on Vector Biology and Control, or are academic or government experts invited to advise the Organization on policies, guidelines and key actions to support Member States on sound management of pesticides.

Experts invited to this meeting have been selected for their personal expertise and experience in specific aspects of pesticide management, both in agriculture and in public health, and do not represent the position of governments or institutions they may belong to. They are appointed in their personal capacity by either FAO or WHO. In addition, representatives from other Inter-Governmental Organizations (IGOs), pesticide industry and Non-Governmental Organizations (NGOs) also attended the meeting as observers.

Dr Morteza Zaim welcomed all participants on behalf of WHO and expressed his great pleasure in hosting the joint meeting for the first time in Geneva. He thanked all present for kindly having responded to the invitation to participate in the meeting.

Mr Mark Davis, of FAO, noted the absence of Dr Gero Vaagt, former Senior Officer of the FAO Pesticide Management Group, who had been called to other duties. He recalled the long involvement of Dr Vaagt in the organization of this Panel and noted that his experience would be greatly missed. Mr Davis underlined the importance of the guidance which the Panel is providing, in particular to developing countries, which are in the complicated situation of having to balance trade, health and environmental interests.

All participants in the meeting are listed in Annex 1.

2. Opening of the meeting

Dr Lorenzo Savioli, Director Control of Neglected Tropical Diseases, gave the opening address on behalf of Mr Hiroki Nakatani, Assistant Director General of WHO. He welcomed the Panel members from FAO and WHO and colleagues from other UN organizations and the World Bank to the meeting, as well as representatives of industry associations and public interest groups who attended the meeting as observers.

[1] http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/code/en/

Dr Savioli reminded the participants that the Panel has an advisory role to FAO and WHO on policies, guidelines and key actions to support Member States on the sound management of pesticides. He stressed that the strengthening of capacity for judicious and effective management of pesticides is a priority for WHO and that the collaboration with FAO provides an opportunity to ensure complementarity, harmonized and coordinated guidance and support to Member States and other stakeholders on this important issue.

The Director underlined that Integrated Vector Management (IVM) is being promoted by WHO as a key strategy for the sound management of pesticides. Capacity building in the field of public health pesticides is an important element of IVM, in particular given the increased use of insecticides in the health sector in many vector-borne disease endemic countries where resources and infrastructure for such activities are often inadequate.

Dr Savioli noted that important guidance documents are being prepared by the Panel and requested the meeting to ensure that these are pragmatic and useful to the main target groups, which are governments of developing countries and countries with economies in transition. He emphasized that the Code of Conduct serves as a framework and guiding document for both FAO and WHO and invited the Panel to carefully review the Code and advise whether any improvements can be made to the document to better address the specific needs of public health pesticides.

Finally, Dr Savioli, wishing the meeting success and stating he looked forward to its recommendations, declared the 2nd FAO/WHO Joint Meeting on Pesticide Management open.

3. Election of the chairperson and rapporteurs

Dr Vibeke Bernson was elected Chairperson of the meeting, and Dr Gamini Manuweera and Dr Sandhya Kulshrestha were appointed rapporteurs.

4. Adoption of the agenda

One additional issue was included under agenda item 13: counterfeiting and illegal trade in pesticides.

The definitive agenda was adopted as shown in Annex 2.

5. Developments since the previous session of the Panel

A brief summary was presented of some important developments with respect to pesticide management that had taken place since the 1st Joint Meeting in October 2007.

5.1 WHO

Chemical safety

WHO Chemical Safety is in the process of updating the Poisons Information Monographs (PIMs) on dieldrin, endosulfan, paraquat and aluminium phosphide. PIMs are concise but comprehensive, internationally peer-reviewed documents about individual agents or groups of agents to which poisoning exposures may occur. The PIMs are primarily intended to facilitate the work of poison information specialists and clinicians in dealing with poisoning cases. They summarize the physico-chemical and toxicological properties of the substance, the clinical features of poisoning and patient management. These will be available on the INTOX and INCHEM websites[2].

Chemical Safety has also developed International Chemical Safety Cards (ICSCs). ICSCs summarize essential product identity data and health and safety information on pure chemicals for use by workers and employers, agriculture and for the public at large. There are now approximately 150 ICSCs on pesticides, available through the WHO web page of the International Programme on Chemical Safety (IPCS)[3].

Chemical Safety is undertaking a risk assessment of the use of DDT in indoor residual spraying for malaria prevention. The draft document will be released for public and peer review, followed by an expert meeting.

Food safety

The 2008 FAO/WHO Joint Meeting on Pesticide Residues (JMPR) was held in Rome, Italy, in September 2008. The meeting evaluated 26 pesticides, of which six were new compounds and six were re-evaluated within the periodic review programme of the Codex Committee on Pesticide Residues (CCPR).

JMPR consists of the FAO Panel of Experts on Pesticide Residues in Food and the Environment and the WHO Core Assessment Group. During the Meetings, the FAO Panel of Experts is responsible for reviewing residue and analytical aspects of the pesticides under consideration, including data on their metabolism, fate in the environment and use patterns, and for estimating the maximum residue levels that might occur as a result of the use of the pesticides according to good agricultural practices. The WHO Core Assessment Group is responsible for reviewing toxicological and related data and for estimating, where possible, acceptable daily intakes (ADIs) for humans of the pesticides under consideration. Relevant information is accessible on the respective JMPR websites of FAO and WHO[4].

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[2] http://www.inchem.org and http://www.intox.org

[3] http://www.who.int/ipcs/publications/icsc/en/index.html

[4] http://www.who.int/ipcs/food/jmpr and http://www.fao.org/ag/AGP/AGPP/Pesticid/JMPR

Evidence, research and action on mental and brain disorders

Pesticide ingestion accounts for over 60 percent of suicides in many rural areas of China and South-East Asia and there is evidence of increased pesticide self-poisoning in Central and South American, as well as African countries. The WHO Team of Evidence, Research and Action on Mental and Brain Disorders of the WHO Department of Mental Health and Substance Abuse held a meeting in Nonthaburi, Thailand, in December 2007 to launch the global public health initiative *The Impact of Pesticides on Health: Preventing Intentional and Unintentional Deaths from Pesticide Poisoning*. The meeting identified actions for safer access to pesticides through community interventions.

The Team also published *Prevention of suicidal behaviours: Feasibility demonstration projects on community interventions for safer access to pesticides*[5]. The document provides draft protocols for the demonstration of feasibility of community-level interventions for safer access to pesticides and the identification of potential sites where to conduct those demonstration projects. The Team also convened a meeting on *Prevention of Suicidal Behaviours: Clinical Management of Acute Pesticide Intoxication*, in Nonthaburi, Thailand, in December 2007. The purpose of this meeting was to do an in-depth review of guidelines on the clinical management of acute pesticide intoxication and to develop clinical guidance for health care workers at different levels of the health care system (i.e., primary health care, district hospitals and specialized units) and a strategy for implementation.

Global Malaria Programme

The Global Malaria Programme (GMP) has produced an update on the WHO Position statement on DDT: The *Use of DDT for Malaria Control*, which includes increased focus on occupational and environmental safety guidance.

The GMP has been collaborating with UNEP and the Secretariat of the Stockholm Convention on Persistent Organic Pollutants (POPs), in providing technical support to countries for capacity building in the use of DDT according to the provision of the Convention. In this context, the Secretariat of the Convention has signed a memorandum of understanding with WHO to support countries in fulfilling their requirements for reporting to the Secretariat on the production and use of DDT for disease vector control.

Two national workshops on DDT reporting were held in 2008, respectively in Rabat, Morocco and in Sana'a, Yemen. Both workshops were preceded by a field visit conducted on assessment and support for safe storage of DDT. In July 2008 a three day inter-regional workshop was held in Bangkok, Thailand to improve the relevant processes for data collection, reporting systems and DDT stocks management in each of the participating countries, i.e., China, Democratic People's Republic of Korea, India, Myanmar, Papua New Guinea and Solomon Islands. As part of these regional and country workshops support was also given to countries to assess the capacities of countries for environmentally sound management of DDT stocks and wastes and discuss the introduction of alternatives to DDT and the strategies to be used to reduce the reliance on DDT.

[5] http://www.who.int/mental_health/resources/suicide/en/index.html

WHOPES

The WHO Pesticide Evaluation Scheme (WHOPES) finalized the testing and evaluation of 5 pesticide products and developed recommendations on their use in public health[6]. The reports of the WHOPES Working Group meetings provide critical reviews of existing literature as well as of studies organized and supervised by WHOPES. These reports are widely distributed among national control programmes, registration authorities and other stakeholders and are intended to facilitate the registration and safe and effective use of such products by Member States.

The 7th FAO/WHO Joint Meeting on Pesticide Specifications (JMPS), held in Braunschweig, Germany, in June 2008, reviewed data package of 19 manufacturers of pesticides (ten for FAO specifications; two for WHO specifications; and seven for joint FAO/WHO specifications) and made recommendations for the development of quality standards for these products.

In collaboration with FAO, WHOPES developed a training manual on the development of pesticide specifications. This tool provides a step-by-step approach to acquiring the knowledge and skills for basic decision-making on the development of pesticide specifications, including the determination of equivalence, following the principles, criteria and procedures detailed in the *Manual on development and use of FAO and WHO specifications for pesticides*[7]. The planned training activities of the two Organizations are expected to support capacity building of the national programmes in the implementation of the Code of Conduct, especially as it relates to Article 6.1.4.

The sixth meeting of the Global Collaboration for Development of Pesticides for Public Health (GCDPP) was held at WHO headquarters, in April 2008. The meeting was attended by representatives of industry, national and government-supported agencies, regional and international organizations, and universities and research institutions, as well as several WHO resource persons, mainly from pesticide registration authorities. The meeting discussed the draft FAO/WHO guidelines on registration of pesticides and advised WHO on the refinement of the guidelines so that they are pragmatic and useful for the main target groups.

WHOPES is in the process of peer review of three generic risk assessment models for application of insecticides in indoor residual spraying, space spraying and mosquito larviciding, as well as three efficacy guidelines for mosquito skin repellents, ground-applied space spray products and household insecticide products. All six guidelines are expected to be published by mid-2009.

Housed in the WHO Vector Ecology and Management Unit, WHOPES has supported the activities of the Unit in supporting Member States in incorporating the principles IVM into their national policies. IVM is highly promoted by WHO for the optimal use of resources for vector and public health pest control and as a key strategy for sound management of pesticides.

WHOPES has also, in collaboration with WHO Regional Offices, initiated situation analyses and needs assessments for strengthening capacity on sound management of pesticides in 12

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[6] http://www.who.int/whopes/recommendations/wgm/en/

[7] http://whqlibdoc.who.int/publications/2006/9251048576_eng_update2.pdf

priority countries in Asia, Africa and South America, through multi-sector and multi-stakeholder approaches. WHOPES also attended the WHO/EURO meeting on Sound Management of Pesticides – Risk Reduction, in Bonn, Germany, in August 2008. The meeting was attended by representatives of 18 Member States, mainly from Eastern Europe, the Caucasus and Central Asia, and recommended on actions to reduce risks associated with the use of such chemicals in agriculture and health.

5.2 FAO

Organizational changes

The Panel was informed that the Plant Production and Protection Division, which hosts the pesticide management programme at FAO, is going through a process of restructuring which should lead to closer integration of crop production and protection activities. Issues related to pesticide management used to be handled by the Pesticide Management Group, but will now be under a Programme Entity responsible for the reduction of risks associated with pesticide use in agriculture to protect human health and the environment, which has three main objectives:

- implementation of the Code of Conduct, including the progressive elimination of highly hazardous pesticides. This objective also covers the work of the JMPR and the JMPS;
- national capacity building for implementation of the Code of Conduct. This objective covers, among other activities, human health risk assessment, strengthening of laboratory capacity, the development of national action plans, implementation of IPM, the safeguarding of obsolete pesticides stocks, etc.;
- communication, knowledge management and associated capacity building services in support of pesticide risk reduction, which includes such activities as the development of guidelines in support of the Code of Conduct, the deployment of pesticide stock management systems, the publication of the joint FAO/WHO training manual on pesticide specifications, information tools on herbicide resistance, etc..

Furthermore, the departure of the Senior Officer Pesticide Management at FAO has led to a reassignment of tasks to other staff within AGP. However, it has also led to a reduction in capacity to implement some of the planned activities related to pesticide management, including some recommendations made previously by the Panel. It is expected that this post will be filled again by mid-2009.

Food safety

The Codex Committee on Pesticide Residues (CCPR) met for its 40th Session, in Hangzhou, China, in April 2008. In addition to the adoption of (draft) Maximum Residue Limits (MRLs) and the revocations of some existing MRLs, the CCPR discussed options for setting globally harmonized MRLs through Codex. This might be achieved by the definition of Codex MRLs before most national MRLs have been set. The implications of such a system on the work of the CCPR and the JMPR would be considerable, though, and these will be further evaluated before the next session. The report of the CCPR is available on the Codex web site[8].

[8] http://www.codexalimentarius.net/web/archives.jsp?year=08

In addition to the work carried out by the JMPR in 2008 referred to under section 5.1, the attention of the Panel drawn to the ongoing FAO/WHO-IPCS project to update principles and methods for the risk assessment of chemicals in food[9].

Minor uses

A Global Minor Use Summit was organized jointly by FAO, the US Department of Agriculture (USDA), the US Environmental Protection Agency (USEPA), and IR-4 Project, at FAO headquarters in December 2007. The summit focussed on finding solution for constraints regarding the generation of data for the registration of pesticides, and other regulatory issues, for minor use or specialty crops.

The summit discussed such issues as the generation of residue data, the promotion of extrapolation of data between different uses (e.g., through zoning or crop grouping), strengthening information and data sharing, and the development of harmonized, global guidance. The final recommendations of the summit can be found on FAO's web site[10].

Obsolete pesticides

Regarding the management and disposal of obsolete pesticides, the Panel was informed that a second phase of the Africa Stockpiles Programme (ASP) is being developed. Noticeably, a much greater emphasis will likely be placed on the importance of sound pesticide management for the prevention of accumulation of obsolete pesticide stocks.

In addition, FAO is in the process of setting up new projects on the management and disposal of obsolete pesticides in Eastern Europe, the Caucuses and Central Asia; the Middle East; the Andean countries and Paraguay; and India and Vietnam (with UNDP).

Rotterdam Convention

The number of Parties to the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (the Rotterdam Convention) continues to increase its scope and impact. The number of Parties increased to 126, while national implementation plans for the Convention have been developed for 52 countries, and is continuing.

The Chemical Review Committee, in March 2008, recommended the inclusion of two new pesticides into its Annex III (the PIC procedure): aldicarb and alachlor. Furthermore, the upcoming Conference of Parties of the Convention, later in October 2008, will consider the inclusion of the pesticides TBT and endosulfan into Annex III.

Trends in international agriculture

The year 2008 has seen the emergence and increased importance of a number of global issues which have a direct impact of agricultural production, such as spiralling food prices, the promotion of bio-fuels and the consequences of climate change. These trends have focused international attention on agriculture again, after a long period of relative neglect. The implications of these global trends on (increased) pesticide use are already being noted. This underlines the importance of continued efforts to ensure sound pesticide management.

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[9] http://www.who.int/ipcs/food/principles/en/

[10] http://www.fao.org/ag/AGP/AGPP/Pesticid/

Monitoring implementation of the Code of Conduct

The previous session of the Joint Meeting discussed two *ad hoc* cases of monitoring observance of the Code of Conduct.

In response to the provisions of the Guidelines on Monitoring and Observance of the Code of Conduct, and in particular its Annex I, FAO sent out an invitation to provide a Regular Monitoring Report on implementation of the Code of Conduct to all its member countries, in July 2008. The deadline for receipt of reports was set at 30 October 2008.

Results of this monitoring exercise will be analysed in the course of 2009, and a report on implementation of the Code of Conduct in FAO member countries should be available at the next session of the Joint Meeting. The report should assist FAO, WHO and the Panel in identifying and/or strengthening priorities for further implementation of the Code of Conduct.

5.3 UNEP

UNEP Chemicals presented its activities for strengthening sound management of pesticides, much of which is carried out in support of SAICM and chemicals-related multilateral agreements. They include activities related risk assessment, management and communication, such as:

- facilitating development of tools for guidance and training in methods for risk assessment and management to be used in capacity building in developing countries and economies in transition;
- promoting the development, exchange and communication of information on reduction of chemicals exposures and effects of chemicals on in particular for sensitive groups and ecosystems;
- supporting activities to minimize effects of natural disasters and industrial accidents involving chemicals;
- mainstreaming of chemicals management into national development agendas.

Pesticide risks

A particular issue with respect to pesticides which UNEP intends to focus on over the next few years are the environmental risks of pesticides in the tropics. In this respect, limited funding has been programmed for the period 2009 – 2011.

Information systems

Several information systems have been put in place, which are of particular relevance for pesticide management:

- the *POPs Laboratory Databank*, a global database of laboratories capable of analyzing POPS. The database provides information, for each laboratory, of the type of analyses that are carried out, the matrices in which POPs can be detected, methods being used, and quality assurance aspects[11];

[11] http://www.chem.unep.ch/databank/Home/Welcome.aspx

- the *Information System on DDT in Disease Vector Control*, which is operated in collaboration with the WHO Global Malaria Programme and the Stockholm Convention[12]. The system provides relevant up-to-date information and guidance on DDT and its alternatives in disease vector control. It was especially developed as a tool for exchanging data, experiences and expertise on the management and use of DDT within and between regions;
- the *Information System on POP Termiticides and Alternatives*, which aims to provide easy access to relevant information and guidance materials on termites and options for their management without POP termiticides[13];
- the *Chemical Information Exchange Network* (CIEN), which was set up as a mechanism to help networking and collaboration among various stakeholders responsible for the environmentally sound management of chemicals[14]. Twelve countries in Africa now have national CIEN web sites to facilitate national information exchange on chemicals;

5.4 Other organizations

The representative of UNITAR informed the meeting about its activities on capacity building for chemicals and waste management. UNITAR is assisting 25 countries in implementing SAICM. It also has a collaborative programme with the Rotterdam Convention, in particular to develop national action plans for its implementation.

The participants were also informed about activities related to pesticide risk reduction carried out by the OECD. A number of seminars has been organised on specific topics, in which non-OECD countries have taken part, the latest of which was the workshop on *Risk Reduction through Better Worker Safety and Training*. Its report has been published earlier in 2008[15].

The Pesticide Action Network (PAN) brought to the attention of the meeting that it had taken up the issue of risk reduction from highly hazardous pesticides (HHPs). A community monitoring exercise had been started to collect information of human health effects caused by pesticides. Furthermore, a first draft of a list of HHPs is presently being elaborated by PAN.

[12] http://www.chem.unep.ch/ddt/Default.html

[13] http://www.chem.unep.ch/termites/Default.html

[14] http://jp1.estis.net/communities/cien/

[15] http://www.oecd.org/department/0,3355,en_2649_34383_1_1_1_1_1,00.html

6. Highly hazardous pesticides

6.1 Identifying highly hazardous pesticides

The previous session of the Panel defined a number of criteria to define HHPs. Following publication of these criteria, feedback was received with regard to the clarity of the criteria and their completeness. Therefore, a number of criteria were revisited by the Panel.

WHO classification

A presentation was made by the WHO on the *WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification*[16], in particular the approach taken for the inclusion of certain chronic hazards (the "CMR" criteria: carcinogenicity, mutagenicity and reproduction toxicity). At present, pesticides classified by the International Agency for Research on Cancer (IARC) as having a high likelihood of being carcinogenic, are specifically identified in the WHO Classification. Reproductive toxicity is taken into account on a case-by-case basis, but not all pesticides listed in the classification have been evaluated against this hazard.

Concern was expressed that CMR hazards have not been, and are presently not, systematically evaluated for all pesticides listed in the WHO Classification. It therefore, contrary to acute hazards, may not provide a complete classification of CMR hazards. However, the only other global hazard classification, the *Globally Harmonized System for the Classification and Labelling of Chemicals* (GHS)[17], while providing criteria for CMR hazards, does not evaluate individual pesticides against these criteria. Systematic evaluation of individual pesticides against the CMR criteria of the GHS, and inclusion of its results in the WHO Classification, would according to the Panel be extremely useful.

The Panel underlined the longstanding use and great importance of the WHO Classification for many aspects of pesticide management and regulation, in particular in developing countries. It noted its wide use in registration, classification and labelling, among others.

The Panel reiterated its previously expressed concern that that the acute toxicity classifications of the WHO system and of the GHS have not yet been harmonized. It therefore recommended that WHO, as soon as possible, harmonize its criteria for acute toxicity with those of the GHS. The Panel further recommended that WHO should assess the feasibility of incorporating the GHS CMR criteria, and possibly other relevant endpoints, into its Classification. Pesticides listed in the Classification would subsequently need to be evaluated against these criteria, so that the WHO Classification can be considered comprehensive and complete, not only for acute hazards but also for the most important chronic hazards. The Panel recognized, however, that such evaluations would require considerable resources.

Endocrine disrupting pesticides

Endocrine disrupting effects were not incorporated into the list of criteria for HHPs as defined by the previous session of the Panel. A presentation was therefore made by PAN on the status of knowledge about endocrine disrupting pesticides.

[16] http://www.who.int/ipcs/publications/pesticides_hazard/en/

[17] http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html

It was stressed in this presentation that endocrine disruption by chemicals should not be considered an emerging issue anymore. Much scientific work has been carried out on the effects of endocrine disruption and the toxicological and physiological explanatory mechanisms. A summary of these mechanisms, as well as the resulting adverse effects, was presented to the Panel.

PAN noted that a number of countries have started taking action in regulating endocrine disrupting chemicals, including pesticides. As a first step, several countries, such as the European Union, Japan and the United States of America have started listing potential endocrine disrupting chemicals and identifying those that require further regulation. Furthermore, the OECD has initiated a research programme which is expected to lead, shortly, to a battery of new and revised testing guidelines to detect endocrine disruptors.

It was recognized in the presentation that there still is no full understanding of all the mechanisms by which pesticides affect the endocrine system, and the adverse effects this may cause. However, PAN was of the view that there is sufficient information on endocrine disrupting pesticides, with assay guidelines well developed by OECD in conjunction with the European Union, Japan and the United States of America, to move forward and regulate at least those pesticides already identified by the European Union. As a result, PAN urged FAO and WHO to include endocrine disruption as a criterion for HHPs.

The Panel welcomed the considerable advancements in the development of harmonized testing guidelines and evaluation criteria for endocrine disrupting chemicals. However, it noted that the OECD harmonized testing guidelines had not yet been published, and the European Union list of likely endocrine disrupting chemicals requiring regulation had not yet been formally adopted. Furthermore, there is still much discussion about the variety in effects that may be caused by endocrine disruptors, questions regarding potency, and effective approaches to assess their actual risk. The Panel also noted that endocrine disruption is not a toxicity endpoint as such and often will lead to toxic effects such as cancer or reproductive effects. Such effects would be covered by the criteria for HHPs.

The Panel, therefore, felt it was premature to include specific reference to endocrine disruptors as a separate category of highly hazardous pesticides. However, the Panel recognized that endocrine disruption can be an important mechanism of pesticide hazard expression. It was recommended that this issue be closely followed, and that the Panel should review the extent to which the existing criteria address endocrine disrupting pesticides at one of its future sessions.

Criteria for HHPs

Based on its discussions, and with the aim to ensure that its criteria for HHPs are clear and unequivocal, the Panel recommended that the criteria published at its 2007 session be slightly revised, and read as follows.

Highly hazardous pesticides should be defined as having one or more of the following characteristics:

- pesticide formulations that meet the criteria of classes Ia or Ib of the *WHO Recommended Classification of Pesticides by Hazard*;

  or

- pesticide active ingredients and their formulations that meet the criteria of carcinogenicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

  or

- pesticide active ingredients and their formulations that meet the criteria of mutagenicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

  or

- pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

  or

- pesticide active ingredients listed by the *Stockholm Convention* in its Annexes A and B, and those meeting all the criteria in paragraph 1 of annex D of the Convention;

  or

- pesticide active ingredients and formulations listed by the *Rotterdam Convention* in its Annex III;

  or

- pesticides listed under the *Montreal Protocol*;

  or

- pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

With respect to the last criterion, the Panel requested WHO, FAO and UNEP to develop workable criteria on how to determine whether pesticide active ingredients and their formulations have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

Pesticide industry representatives indicated that criteria to identify highly hazardous pesticides which are entirely hazard-based would not be supported by them, and risk assessment should be the basis for regulatory decision making.

6.2 Priority activities for risk reduction

The Panel recalled the recommendation made by the 131st session of the FAO Council, in 2006, with respect to FAO's contribution to SAICM, which read:

In view of the broad range of activities envisaged within SAICM, the Council suggested that the activities of FAO could include risk reduction, including the progressive ban on highly hazardous pesticides, promoting good agricultural practices, ensuring environmentally-sound disposal of stock-piles of obsolete pesticides and capacity-building in establishing national and regional laboratories.

The previous session of the Panel made a number of recommendations with respect to risk reduction of HHPs. FAO informed the meeting that regrettably little progress had been made with implementation of these recommendations, to a large extent due to limitations in personnel (see section 5.2). FAO stressed, however, that risk reduction of HHPs would remain a high priority in its programme, as recommended by the FAO Council.

The previous Panel recommendation that FAO and WHO, as a first step, prepare as list of HHPs based on the criteria identified, had not been taken up. FAO indicated it would be very hesitant to develop such a list, since its relationship to existing Multilateral Environmental Agreements (MEAs) that have more extensive identification procedures, in particular the Rotterdam Convention, might cause confusion in implementation at country level. In addition, preparing a list of individual pesticides classified as a HHP will likely result in long and complicated discussions, which may divert attention from the main task of reducing the risks posed by HHPs.

FAO therefore suggested that the first step of implementing the criteria defined by the Panel may be to develop guidance for registrars on how to apply the criteria for the national authorization of pesticides. Such guidance would also include available relevant data sources needed to use the criteria, and advice on elements and procedures for decision making, in particular with respect to viable alternatives for HHPs. As a second step, FAO and WHO could then actively engage regulators at the national level and assist them in implementing risk mitigation measures for HHPs.

The Panel stressed that registrars in many developing countries need clear guidance on what should be considered HHPs and what type of risk reduction measures can be taken. At present, most countries concerned already lack manpower and technical expertise to carry out proper hazards assessment for pesticides, let alone complete risk assessments.

The Panel revisited its previous recommendations made on priority activities for risk reduction. It noted that most of these recommendations still stand, but suggested to make a number of amendments to further clarify actions that should be taken to reduce risks that are posed by HHPs.

The Panel noted that many HHPs are currently in use, and reiterated that substituting them by less hazardous pest management options will often take time. However, as a general principle, the Panel recommended that HHPs should not be registered for use unless:

i. governments establish a clear need;

ii. no alternatives, based on a risk – benefit analysis, are available; and

iii. control measures as well as good marketing practices are sufficient to ensure that the product can be handled with acceptable risk to human health and the environment.

The Panel considered that the following activities should be a priority for FAO and WHO, with the aim to reduce the risks from HHPs, which explicitly could include a progressive ban of these compounds:

- FAO and WHO, as a first step, should make available to countries information on HHPs based on the criteria above, update it periodically in cooperation with UNEP, and make it widely known;
- FAO, in collaboration with WHO, should invite governments and the pesticide industry to develop plans of action to reduce risks from HHPs by taking regulatory or technical

action, either at the national or the regional level as appropriate, taking into account the work undertaken in existing MEAs such as the Stockholm Convention, Rotterdam Convention and the Montreal Protocol;

- FAO, in collaboration with WHO, should collect information on alternatives for HHPs, both reduced risk pesticides and other pest management approaches, in cooperation with all relevant stakeholders, and share experiences among countries;
- FAO, in collaboration with WHO, should seek assistance from donors for countries which wish to act to reduce risks from HHPs with the aim of preparing, implementing and enforcing action plans and search for alternatives;
- FAO should mobilize internal and external resources in order to implement, as a priority, the recommendations of the FAO Council with respect to HHPs.

The Panel underlined that effective risk reduction from HHPs is mainly carried out at the national level, and that national governments thus have the prime responsibility in this respect. It therefore recommended that FAO, in collaboration with WHO, invite national governments to ensure that at least the following risk reduction measures for HHPs are taken into account:

- identify HHPs with help of the criteria explained above;
- review the need for the use of HHPs, while simultaneously reviewing use conditions, mitigation measures and comparative risk assessment;
- where a specific need is identified for a HHP and no viable alternatives are available, governments should be advised to take all the necessary precautions, mitigation measures and apply restrictions, that may include the use only under certain conditions or by specifically certified users, severe restrictions, or a possible phase-out;
- promote the use of alternative pest management strategies and, in case they are not available, promote research for development of alternative strategies;
- promote the substitution principle for HHPs;
- ensure the provision of sufficient advice and information to users.

Finally, the Panel noted that the Global Guide to Resources on Acute Toxic Pesticides, which had been prepared by the Intergovernmental Forum on Chemical Safety (IFCS) to assist its recommendations on acutely toxic pesticides, is still being updated regularly[18.] The Panel suggested that FAO and WHO, as well as national government, could also use this guide to further identify and implement priority activities for risk reduction of HHPs.

[18] http://www.who.int/ifcs/champions/guide_resources/en/index.html

7. Guidelines in support of the Code of Conduct

As an introduction to the discussions on the various guidelines being developed in support of the Code of Conduct, the Panel was informed of newly published or translated guidelines since the its previous session, in October 2007:

- the publication, in May 2008, of the joint FAO/WHO *Guidelines on Management Options for Empty Pesticide Containers.*[19]
- the translation into French and Spanish of the FAO *Guidelines on Monitoring and Observance of the Code of Conduct*.[20]
- the translation into Arabic of the FAO *Guidelines on Efficacy Evaluation for the Registration of Plant Protection Products*.[21]
- the publication of the FAO Legislative study No. 97 – *Designing National Pesticide Legislation*.[22]

The Panel was also informed that, because of legal requirements at WHO and the wish to operate a consistent guideline drafting procedure within both organizations, FAO and WHO have decided that guidelines in support of the Code of Conduct would in the future only be drafted by independent experts. FAO and WHO underlined that this procedure would be adhered to avoid any appearance of a conflict of interest, and not because there had been any reservation with respect to the technical quality of previous guidelines. Guidelines presently in the process of being drafted are not affected by this change of policy. Pesticide industry associations and public interest groups would continue to be invited to participate in Task Groups for specific guidelines as observers, and provide inputs in the drafting process.

8. Drafting status of guidelines under development

The Panel was presented with the drafting status of a number of guidelines that are presently being developed.

8.1 Guidelines on resistance management for pesticides

The Panel reviewed a first working draft of the *Guidelines on Resistance Management for Pesticides* at its previous session. Additional comments on this draft had been received subsequently and had been incorporated into a second draft by the drafter in close collaboration with the Task Group chair. The second draft had been reformatted by FAO and was being completed by the drafter.

The Panel requested the Task Group chair and the drafter to finalize the draft by January 2009, to be circulated for review by the Task Group and by a limited number of independent

[19] http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/code/frame/implement/obsolete/en/

[20] http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/code/frame/monitor/en/

[21] http://www.fao.org/agriculture/crops/core-themes/theme/pests/pm/code/frame/implement/regpes/en/

[22] http://www.fao.org/legal/legstud/list-e.htm

peer reviewers. External peer reviewers should be selected based on their expertise in pesticide resistance management, both in agriculture and in public health, by FAO and WHO in consultation with the Task Group chair. The Panel recommended that comments received be taken into account in finalizing this draft, and that it subsequently be circulated among Panel members and observers for review, by June 2009. A final version of the guideline should be presented to the Panel for endorsement by October 2009.

8.2 Guidelines on registration of microbial pest control agents

With respect to the *Guidelines on Registration of Microbial Pest Control Agents*, the Panel took note of the fact that a draft had been prepared based on the outline agreed during its previous session. This draft was circulated among the Task Group members and comments were incorporated by the drafter. The second draft will require reformatting, to be in line with the agreed guideline format.

The Panel requested that this draft be finalized and reviewed by the Task Group by January 2009, and subsequently be sent for external peer review. External peer reviewers should be selected based on their expertise in the registration of microbial pest control agents, both in agriculture and in public health, by FAO and WHO in consultation with the Task Group chair. The Panel recommended that the peer review be taken into account in finalizing this draft, and it be circulated subsequently among Panel members and observers for comments, by May 2009. A new version of the guideline should be presented to the Panel for endorsement, by October 2009.

8.3 Guidance on pest and pesticide management policy development – agriculture.

A draft of the *Guidance on Pest and Pesticide Management Policy Development (Agriculture)* had been discussed by the Panel at its previous session. Subsequently, additional comments were provided which differed substantially from each other and did not represent a clear consensus on the changes to be made. This resulted in a new draft of the document, which had not yet been circulated among the Task Group or full Panel.

The Panel discussed the status and process of development of this draft guideline. It requested FAO to circulate the newly revised draft among the Task Group members for review, by January 2009, to assess whether previous comments have been incorporated in an acceptable manner. Since the latest comments were all provided Task Group members, the Panel recommended that the Task Group consider calling an external independent peer review of the guidance document if certain key elements would remain unresolved. The Panel recommended that a final draft then be prepared, and circulated among Panel members for endorsement by June 2009. If no major comments were to be received on the final draft, FAO was requested to finalize the guidance document and subsequently proceed with publication prior to the Panel's next session.

9. Review of outlines for new or revised guidelines

The Panel was presented with one draft outline for a new guideline to be developed.

9.1 Guidelines on retail establishments for pesticides

A revised scope and outline was presented of the *Guidelines on Retail Establishments for Pesticides*, based on the suggestions made the Panel during its previous session. The Panel confirmed its previous recommendation that the guideline should focus on providing advice to governments on the establishment of a proper system and setting minimum requirements of pesticide distribution and sales within the country. Guidance to be provided to retailers was considered to be the main responsibility of individual governments and of the private sector itself.

The Panel underlined the very important role that retailers play in the pesticide management chain, in particular in developing countries, where they tend to be the prime source of information for pesticide users, not only on the products themselves but also on pest management in general. The effective organization and regulation of retail outlets should therefore be a priority and the guideline should provide minimum requirements in this respect.

The Panel made a number of suggestions regarding the contents of guideline, which included:

- ensuring that distribution and sales of all types of pesticides, including agricultural, public health and domestic use products are covered;
- taking into account different types of retail outlets which may cater for different groups of pesticide users (e.g., general public, farmers, professional pest control operators);
- addressing forms of retail specific to many developing countries, such as travelling salesmen and mixed retail shops (e.g., 'one-stop shops' selling all agricultural inputs and materials, or even other types of goods);
- including options for retailer licensing, and the problem encountered in various countries that license holders may not be the actual shopkeepers;
- addressing in sufficient detail elements on labelling, packaging, storage and disposal;
- stressing the need to avoid the risk of food contamination during storage;
- covering all articles of the Code of Conduct which are relevant of pesticide distribution and sales.

In addition, the Panel underlined the importance of training of and information provision to pesticide distributors and retailers, and of effective enforcement, and requested that this be taken into account in the guideline.

The Panel requested that FAO and WHO prepare a detailed annotated table of contents for this guideline by March 2009, and circulate it among Panel members and observers for comments. The Panel further recommended that the development of the guideline be initiated as soon as possible afterwards, so that a complete draft can be distributed for discussion at its next session.

10. Review of new and revised guidelines

The Panel was presented with three draft guidelines presently under development.

10.1 Guidelines on the development of a reporting system for health and environmental incidents resulting from exposure to pesticides

A draft version of the *Guidelines on the Development of a Reporting System for Health and Environmental Incidents Resulting from Exposure to Pesticides* had been discussed during the previous session of the Panel. Comments made by the Panel were incorporated and the draft went subsequently through an additional review round by a number of Panel members, observers and external reviewers. A final draft was then prepared and had been distributed to the Panel for endorsement.

The Panel commended the drafter for her excellent work in finalizing this guideline. The Panel recognized the importance of having a feedback system on possible adverse impact of pesticides within the country as a basis for effective interventions through policy and other options. While recognizing that the operation of a thorough and effective pesticide incident reporting and monitoring system is very complex and will require considerable resources, the Panel underlined that this guideline can provide guidance on how to initiate such a system.

The Panel endorsed in principle the present version of the guideline, but requested that a number of clarifications be made to certain sections of the text. These included:

- adding and/or amending certain definitions;
- providing a good description of the circumstances of pesticide exposure, and the addition of certain elements to the report of suspected pesticide poisoning cases;
- including a recommendation for mandatory reporting of health and environmental incidents;
- providing more guidance on the verification of incident reports.

The Panel recognized that cases of pesticide poisoning as a result of suicide attempts will have very different policy implications from occupational and accidental cases. However, it recommended that reporting and assessment of suicide cases also be included in the guideline.

The Panel noted that for the guidelines to be effective, many countries will likely need capacity building in various aspects of incident reporting and analysis. The Panel also stressed the need of field-testing this guideline and obtaining feedback about the feasibility of its recommendations and its usefulness, and noted the willingness of individual members and of UNEP to do so. It was underlined that a reporting system is only one of the building blocks in protecting human health and the environment as part of sound pesticide management.

The Panel requested that a definitive draft be circulated to its members for final endorsement by November 2008, and that FAO and WHO, after formatting and editing, proceed with publication of the guideline no later than March 2009.

10.2 Guidelines on registration of pesticides

Based on the outline agreed upon at the previous session of the Panel, a draft of the *Guidelines on Registration of Pesticides* had been prepared. This initial draft had been discussed at the 6th GCDPP Meeting in April 2008, in which most of the members of the Task Team for this guideline participated. The comments and suggestions provided during the meeting were subsequently incorporated in a revised draft, which had been circulated among Panel members and observers.

The Panel was reminded of the fact that the purpose of the guideline is to provide general advice on the principles and process as well as requirements for registration of pesticides, including institutional and administrative organization. It should be considered as an umbrella document with more detailed guidance on technical elements of the registration process (such as data requirements, testing methods or risk assessment procedures) to be provided in separate guidelines.

The Panel expressed its appreciation regarding the advanced status of development of the document. It stressed that an effective pesticide registration system is a vital element for sound management of pesticides in a country, and requires a multi-disciplinary approach in implementation.

The Panel considered that the overall scope and contents of the guideline were appropriate for its purpose, and raised a number of issues that might be considered when finalizing the document. These included:

- limiting the section on the responsibilities of various stakeholders to those that are directly involved in pesticide registration;
- considering to extend the definition of 'pesticide' to the one used by the JMPS, so that public health and domestic use pesticides are more clearly included;
- explaining different types of registration in more detail;
- providing more information on registration by equivalence;
- clarifying and correcting the section on data protection, by limiting it to a description of principles but avoiding to take a specific position, as this was not done in the Code of Conduct;
- ensuring that issues regarding transparency of the registration process and public information are properly covered;
- providing more guidance on the use of existing data and data exchange between registration authorities;
- including experimental permits, and providing more detail on registration options for minor uses and biopesticides;
- providing additional guidance on comparative risk assessment and the substitution principle;
- clarifying the various options and requirements for fast-track registration.

The Panel further confirmed that genetically modified organisms or natural enemies of pests would not be covered by the guideline. It requested FAO and WHO to carry out a legal review of the guideline to avoid inconsistencies or errors.

The Panel recommended to extend the commenting period until 31 December 2008, after which a new draft should prepared and circulated among Panel members for endorsement, no later than March 2009. The Panel requested that, if no major comments are received, FAO and WHO, after formatting and editing, proceed with publication of the guideline.

10.3 Guidelines on pesticide advertising

With respect to the *Guidelines on Pesticide Advertising*, the Panel took note of the new draft which had been prepared by the Task Group chair and the written comments provided on this document.

The draft of the guidelines as presented to the Panel suggests that for certain types of advertisements, the provisions of Article 11.2 do not necessarily need to be observed. This would be the case, for instance, for small promotional items such as pens which may not have enough space to show the required wording. While recognizing that such physical constraints could exist for certain types of promotional items, the Panel underlined that no exemptions should be made in this guideline for provisions in the Code of Conduct. Therefore, the Panel recommended that the provisions of Article 11 in the Code of Conduct would need to apply to all forms of pesticide advertising, and that the guidelines reflect this clearly.

The Panel discussed the need to provide further guidance on Article 11.2.18 of the Code of Conduct which states that *Pesticide industry should ensure that advertisements and promotional activities should not include inappropriate incentives to encourage the purchase of pesticides*. The previous session of the Panel recommended that examples be given of what can be considered appropriate and inappropriate incentives or gifts, to assist regulators in the application of this article to their national situation. Examples were subsequently provided in the new draft of the guideline.

The draft guidelines provide a general definition of 'inappropriate' which reads: *In general terms, an incentive may be considered appropriate if it is in line with the objectives of the Code of Conduct, and inappropriate if it runs counter to these objectives, i.e. if it encourages the purchasing of a pesticide for another reason than to make the best choice to control a pest or disease*. This definition was considered by some observers as too narrow, as the 'best choice' could be interpreted as being limited to biological reasons, but excluding convenience of use, price, etc. Such an interpretation would then disallow advertising to encourage 'brand change'. It was suggested to modify the latter part of the phrase into: *make the best choice for cost-effective control a pest or disease.* However, the Panel considered this an equally narrow interpretation, and suggested clarify that the best choice will need to be made for agronomic, economic, environmental and health reasons.

Concern was expressed about the use of specific examples in the guidelines, as they can never be exhaustive, and are highly dependent on social, economic, cultural and religious circumstances. A replacement text was therefore presented to the Panel of a more generic nature. The Panel discussed both the draft guideline text and the proposed replacement and concluded that inclusion in the guidelines of explicit examples of inappropriate incentives

would be helpful to national regulators. It considered that the draft guideline clearly stresses that the exact interpretation of this article is subjected to the national or local situation.

The Panel therefore concluded that a list of examples of inappropriate (but not of appropriate) incentives of gifts should be provided in the guideline, such as, but not necessarily limited to:

- incentives or gifts which are not related to the product advertised;
- incentives or gifts with a value higher than the product advertised, unless it is related to the judicious use of the product in question (e.g., personal protective equipment, sprayer maintenance equipment);
- incentives or gifts in exchange of the product label, as this leads to unlabeled products in the hands of the end-user.

The suggestion made to refer in the guidelines to the International Chamber of Commerce (ICC) Code of Advertising and Marketing Communication Practice[23] (and in particular Chapter A on Sales promotion) as minimum general provisions regarding the use of incentives, was supported by the Panel.

The guideline leaves it at the discretion of governments and other stakeholders to notify FAO or WHO of cases of non observance of the provisions of the Code of Conduct on advertising. FAO and WHO may decide to review such notifications. It was suggested that a summary of such complaints and the outcome of the review should be made publicly available by FAO or WHO. The Panel did not support this suggestion, since the *ad hoc* monitoring procedure of observance of the Code of Conduct, set up by FAO, is not a formal international complaints procedure[24.]

CropLife International noted that, at this point in time, it could not agree with the Panel recommendations on this guideline, but would provide a definitive statement on its acceptance after having reviewed the final draft.

The Task Group was requested to incorporate the recommendations made during the meeting, as well as any editorial comments as far as appropriate. The Panel further requested that the final draft of the guidelines be reviewed again for any legal inconsistencies.

The Panel recommended that the Task Group prepare a new draft of the document by January 2009, for subsequent circulation among the Panel members for endorsement. The Panel requested that, if no major comments are received, FAO and WHO, after formatting and editing, proceed with publication of the guideline no later than June 2009.

[23] http://www.iccwbo.org/policy/marketing/id8532/index.html

[24] http://www.fao.org/ag/AGP/AGPP/Pesticid/Code/Guidelines/Monitoring.htm

11. Guidelines proposed for updating

The Panel discussed two guidelines which had been proposed for updating during a previous session.

11.1 Guidelines on pesticide legislation

The Panel was presented with the recently published *FAO Legislative Study on Designing National Pesticide Legislation,* and commended its quality and clarity.

The Panel underlined that the existing FAO guidelines on pesticide legislation are outdated and do not cover all pesticide uses addressed in the Code of Conduct, and reiterated its previous recommendation to develop updated guidelines on this issue. The Panel discussed in which ways the presented legislative study could be used as a basis for the elaboration of a new guideline on pesticide legislation, which would need to cover all areas of pesticide use, including public health and domestic uses.

The Panel recommended that FAO and WHO initiate the development of an outline for a new guideline on pesticide legislation, to be presented for consideration by the Panel at its next session.

11.2 Guidelines on good labelling practice for pesticides

The Panel was informed that no progress had yet been made in updating this document. The Panel stressed the importance of effective labelling of pesticides as a prime tool for communication with the user.

The Panel revisited its previous recommendation to present the WHO and GHS classifications for pesticides in a parallel manner in the guidelines, since these two systems had not yet been harmonized. It agreed, however, that clear advice on pesticide labelling needs to be provided to countries and a double-track system should be avoided. Furthermore, countries have started implementing GHS and require specific guidance on how to apply this to pesticide labelling.

The Panel noted that while the GHS is to become the global standard for classification and labelling of chemicals, the FAO guidelines and WHO classification of pesticides have long history of use in many countries, and that users have grown accustomed to this approach. The Panel therefore supported the proposal to update the guideline, taking into account the GHS but ensuring that the existing guideline is not changed more than absolutely necessary.

The Panel requested that a first draft be circulated among Panel members and observers by January 2009.

12. Implementation of the Code of Conduct

Although a large number of activities are being carried out by international organizations, national governments, the private sector and civil society organizations, which contribute to the implementation of the Code of Conduct, continued efforts to promote the sound management of pesticides are still needed, in particular in developing countries and countries with economies in transition. The Panel was therefore invited to discuss ways and means of strengthening implementation of the Code over the next few years.

A number of issues were put forward, regarding a possibly reorientation of implementation of the Code, among them:

- increased focus on national implementation, by favouring the development of national projects and programmes;
- better orientation of guidance and guidelines to the needs to developing countries and including systematic verification of their usefulness;
- closer integration of pest management, pesticide management, sustainable intensification of crop production, integrated vector management, chemicals management, environmental issues;
- mainstreaming of awareness building on the Code in the regular work of FAO, WHO and UNEP.

It was proposed to develop a programme for implementation of the Code of Conduct, which would build on a strategic approach based on four main elements: **i.** *normative work* at the international level (e.g., guidelines, policies, forums), which would guide to **ii.** *capacity building* on technical and policy issues (e.g., training, information exchange) at national and regional levels, which would lead to **iii.** *implementation* projects and programmes, primarily at the national level, which in turn would require **iv.** *feedback* mechanisms to assess effectiveness of implementation. By having the feedback direct the normative work again, a 'strategic loop' for implementation of the Code of Conduct could be developed.

The Panel welcomed the initiative to attempt to increase attention and resources for implementation of the Code of Conduct, and agreed that activities at national and regional levels are in particular required. The Panel endorsed the general concept to develop a programme for implementation of the Code of Conduct along the lines set out during the meeting.

The Panel stressed the importance of ensuring the involvement of all stakeholders, since the success of the Code of Conduct is borne by the fact that all major stakeholders have underwritten it. New stakeholders, such as the food sector, should therefore be actively engaged to participate in the programme. Furthermore, the Panel recommended that opportunities be sought to work with other organizations which are members of the Inter-organization Programme for the Sound Management of Chemicals (IOMC) to strengthen work on training, capacity building and implementation of the Code of Conduct.

The Panel stressed the importance of integration of the programme with initiatives such as the *Strategic Approach to International Chemicals Management* (SAICM) and the *2nd International Conference on Chemicals Management* (ICCM-2), with a view to facilitating a more effective implementation of the Code of Conduct.

While FAO, WHO and UNEP are already accessing their regular budgets to fund implementation activities, this will certainly be greatly insufficient to develop an effective programme. The Panel therefore called upon FAO, WHO, UNEP and other meeting participants to identify sources and secure funds for implementation of the programme. The Panel recommended that particular attention be paid to presenting the programme in ways that are attractive to governments and potential donors.

The Panel indicated that its members could contribute to the development of a programme for implementation of the Code of Conduct by identifying important needs and gaps that require attention and key entry points that could help get such a programme started up. Furthermore, the Panel could act as 'steering committee' which would oversee implementation and monitor its effectiveness.

13. Counterfeit pesticides

At the request of CropLife International, the Panel discussed the problem of counterfeit and illegal pesticides.

The Panel was informed of the increasing importance of counterfeit pesticide products, which are estimated to amount to 5-7 percent of the products in Europe and 20-30 percent in developing countries. Apart from causing economic losses to the legitimate pesticide industry, forged pesticides may endanger farmers' livelihoods and health, put the food chain and consumers at risk, and may cause damage to the environment. Counterfeiting also undermines the national regulatory systems. CropLife expressed its concern that legitimate pesticides tend to be strictly regulated but problems of illegal and counterfeit products still get relatively limited attention in many countries.

The Panel recognized the importance of the problems caused by the trade in counterfeit pesticides, and noted that it appears to be related, to a large extent, to weak inspection and control systems in many (developing) countries. Strengthening import and export controls, and developing effective systems of quality control which are also feasible in resource-poor countries, are needed to get to grips with this problem. This will require involvement of many players and stakeholders.

The Panel indicated that it would like to further discuss possible ways of reducing the trade and adverse impact of counterfeit pesticides at a next session.

14. Review of the Code of Conduct

The Panel discussed the scope and objectives of the *International Code of Conduct on the Distribution and Use of Pesticides,* in particular its coverage of public health and domestic pesticides. The Panel noted that the Code of Conduct clearly addresses all pesticides and all areas of use. However, it was recognized that its provisions, definitions and the included references appear to focus more on the management of agricultural pesticides.

The Panel recognized that an even more complete Code of Conduct, which might be jointly published by FAO, WHO and possibly UNEP, would likely increase its visibility and impact. However, concern was expressed at initiating a formal revision of the Code of Conduct, as experience has shown that this would require much time and resources, which might better be used for actual implementation of the Code of Conduct. Any possible updating of the Code of Conduct should therefore be limited in scope and not attempt to amend issues expected to generate much discussion.

The Panel recommended that FAO and WHO start the process to ensure that the Code of Conduct, and its implementation tools, adequately addresses all pesticides, and in particular public health pesticides. As a first step, WHO was requested to prepare a working document indicating which articles of the Code of Conduct might need to be amended or completed to ensure full coverage of public health and domestic pesticides.

15. Recommendations

Based on the working documents reviewed, the presentations made and the discussions held during the meeting, the Panel made the following recommendations:

Highly hazardous pesticides

1. To make further progress on the initiative for the reduction of risks posed by HHPs, the Panel reviewed the recommendations from its 2007 meeting and **agreed** that these recommendations **be adopted with the modifications** as incorporated in the following text:

2. HHPs **should be defined** as having one or more of the following characteristics:

   - pesticide formulations that meet the criteria of classes Ia or Ib of the *WHO Recommended Classification of Pesticides by Hazard*;

   or

   - pesticide active ingredients and their formulations that meet the criteria of carcinogenicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

   or

- pesticide active ingredients and their formulations that meet the criteria of mutagenicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

or

- pesticide active ingredients and their formulations that meet the criteria of reproductive toxicity Categories 1A and 1B of the *Globally Harmonized System on Classification and Labelling of Chemicals* (GHS);

or

- pesticide active ingredients listed by the *Stockholm Convention* in its Annexes A and B, and those meeting all the criteria in paragraph 1 of annex D of the Convention;

or

- pesticide active ingredients and formulations listed by the *Rotterdam Convention* in its Annex III;

or

- pesticides listed under the *Montreal Protocol*;

or

- pesticide active ingredients and formulations that have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

3. The Panel **noted** advancements in the development of harmonized testing guidelines and evaluation criteria for endocrine disrupting chemicals, but felt it was premature to include specific reference to endocrine disruptors as a separate category of highly hazardous pesticides. However, the Panel **recognized** that endocrine disruption can be an important mechanism of pesticide hazard expression. It was **recommended** that the extent to which the existing criteria address endocrine disrupting pesticides be reviewed by the Panel at one of its next sessions.

4. The Panel further **recommended** that WHO, FAO and UNEP develop criteria for determining whether pesticide active ingredients and their formulations have shown a high incidence of severe or irreversible adverse effects on human health or the environment.

5. The Panel discussed how to address the current use of highly hazardous pesticides, and **recommended** that these should not be registered for use unless:

   a) governments establish a clear need;

   b) no alternatives, based on a risk – benefit analysis, are available; and

   c) control measures as well as good marketing practices are sufficient to ensure that the product can be handled with acceptable risk to human health and the environment.

6. The Panel discussed priority activities related to risk reduction from HHPs, including a progressive ban, and **recommended** that:

   a) FAO and WHO, as a first step, make available to countries information on HHPs based on the criteria above, update it periodically in cooperation with UNEP, and make it widely known;

b) FAO, in collaboration with WHO, invite governments and the pesticide industry to develop plans of action to reduce risks from HHPs by taking regulatory or technical action, either at the national or the regional level as appropriate, taking into account the work undertaken in existing Multilateral Environmental Agreements such as the Stockholm Convention, Rotterdam Convention and the Montreal Protocol;

c) FAO, in collaboration with WHO, collect information on alternatives for HHPs, both reduced risk pesticides and other pest management approaches, in cooperation with all relevant stakeholders, and share experiences among countries;

d) FAO, in collaboration with WHO, seek assistance from donors for countries which wish to act to reduce risks from HHPs with the aim of preparing, implementing and enforcing action plans and search for alternatives;

e) FAO mobilize internal and external resources in order to implement, as a priority, the recommendations of the FAO Council with respect to HHPs.

7. The Panel further **recommended** that FAO, in collaboration with WHO, invite national governments to ensure that at least the following risk reduction measures for highly hazardous pesticides (HHPs) are taken into account:

a) identify HHPs with help of the criteria explained above;

b) review the need for the use of HHPs, while simultaneously reviewing use conditions, mitigation measures and comparative risk assessment;

c) where a specific need is identified for a HHP and no viable alternatives are available, governments should be advised to take all the necessary precautions, mitigation measures and apply restrictions, that may include the use only under certain conditions or by specifically certified users, severe restrictions, or a possible phase-out;

d) promote the use of alternative pest management strategies and, in case they are not available, promote research for development of alternative strategies;

e) promote the substitution principle for HHPs;

f) ensure the provision of sufficient advice and information to users.

WHO Classification of pesticides by hazard

8. Given the great importance of the *WHO Recommended Classification of Pesticides by Hazard* for various aspects of pesticide management and regulation, including registration, classification and labelling, in particular in many developing countries, the Panel **expressed its concern** that that the classifications of the WHO system and of the GHS have not yet been harmonized, which impedes the provision of clear guidance on classification and labelling of pesticides.

9. The Panel therefore **recommended** that WHO, as a matter of urgency, harmonize its criteria on acute toxicity with those of the GHS. The Panel further **recommended** that WHO assess the feasibility to incorporate the GHS criteria on carcinogenicity, mutagenicity and reproductive toxicity, and other relevant endpoints, into its Classification and ensure that all pesticides listed have been evaluated against these criteria.

Implementation of the Code of Conduct

10. The Panel discussed the need to strengthen the implementation of the *International Code of Conduct on the Distribution and Use of Pesticides* and **recognized** the importance of its implementation at, in particular, national and regional levels. The Panel **endorsed** the general concept to develop a programme for implementation of the Code of Conduct as presented, and **recommended** that it include a strategy to involve the food sector as an important stakeholder.

11. The Panel **stressed** the importance of integration with initiatives such as the *Strategic Approach to International Chemicals Management* (SAICM) and the *2nd International Conference on Chemicals Management* (ICCM-2), with a view to facilitating a more effective implementation of the Code of Conduct. Furthermore, the Panel **recommended** that opportunities be sought to work with organizations which are members of the Inter-organization Programme for the Sound Management of Chemicals (IOMC) to strengthen work on training, capacity building and implementation of the Code of Conduct.

12. The Panel **called upon** FAO, WHO, UNEP and other meeting participants to identify sources and secure funds for implementation of the programme. The Panel **recommended** that particular attention be paid to presenting the programme in ways that are attractive to governments and potential donors.

13. The Panel **requested** to be kept informed of developments in the elaboration and implementation of the programme.

Guidelines in support of the Code of Conduct

14. The Panel reviewed the drafting status of a number of guidelines which are being developed in support of the Code of Conduct, and made the following recommendations.

    a) With respect to the *Guidelines on Resistance Management for Pesticides*, the Panel took note of the ongoing work to develop a new draft of this guideline, along the lines set out during its previous session. The Panel **requested** the Task Group chair and the drafter to finalize the draft by January 2009, to be circulated for review by the full Task Group and independent peer reviewers. The Panel **recommended** that comments received be taken into account in finalizing this draft, and that it subsequently be circulated among Panel members and observers for review, by June 2009. A final version of the guideline should be presented to the Panel for endorsement by October 2009.

    b) With respect to the *Guidelines on Registration of Microbial Pest Control Agents*, the Panel took note of the fact that a draft had been prepared for this document, based on the outline agreed during its previous session. The Panel **requested** that this draft be finalized and reviewed by the Task Group by January 2009, and subsequently be sent for external peer review. The Panel **recommended** that the peer review be taken into account in finalizing this draft, and it be circulated subsequently among Panel members and observers for comments, by May 2009. A new version of the guideline should be presented to the Panel for endorsement, by October 2009.

c) With respect to the *Guidance on Pest and Pesticide Management Policy Development*, the Panel noted the status of development of this draft and **requested** that, after internal review by FAO, the draft be circulated and commented on by the Task Group, by January 2009, to assess whether previous comments have been incorporated in an acceptable manner. The Panel **recommended** that the Task Group consider calling an external independent peer review of the guidance document if certain elements would remain unresolved. The Panel **recommended** that a final draft be circulated among Panel members for endorsement by June 2009 and that FAO, if no major comments were received, finalize the guidance document and subsequently proceed with publication prior to its next session.

15. The Panel reviewed the draft outline of one guideline which is being developed in support of the Code of Conduct, and made the following recommendations.

    a) With respect to the outline for the *Guidelines on Retail Establishments for Pesticides*, the Panel **underlined** the importance of proper regulation of retail outlets, and **recommended** drafting a guideline focused on providing advice to the governments in the establishment of a proper system of sale of pesticides within the country, including public health and household pesticides. The Panel **provided** several **suggestions** on its content, which included taking into account different types of retail establishments which may sell pesticides; addressing in sufficient detail elements on labelling, packaging, storage and disposal; and stressing the need to avoid food contamination during storage. The Panel **requested** that FAO and WHO prepare a detailed annotated table of contents for this guideline by March 2009, and circulate it among Panel members and observers for comments. The Panel further **recommended** that the development of the guideline be initiated as soon as possible afterwards, so that a complete draft can be distributed for discussion at its next Session.

16. The Panel reviewed a number of draft guidelines that were developed in support of the Code of Conduct, and made the following recommendations.

    a) With respect to the *Guidelines on the Development of a Reporting System for Health and Environmental Incidents Resulting from Exposure to Pesticides*, the Panel **recognized** the importance of having a feedback system on possible adverse impact of pesticides within the country as a basis for effective interventions through policy and other options. The Panel **endorsed in principle** the present version of the guideline, but requested that a number of clarifications be made to certain sections of the text. The Panel **requested** that a definitive draft be circulated to its members for final endorsement by November 2008, and that FAO and WHO, after formatting and editing, proceed with publication of the guideline no later than March 2009.

    b) With respect to the *Guidelines on Registration of Pesticides*, the Panel **stressed** that an effective pesticide registration system is a vital element for sound management of pesticides in a country, and requires a multi-disciplinary approach in implementation. The Panel **made suggestions** for improvements to various sections of the draft, including the responsibilities of various actors for pesticide registration; the issue of data protection, transparency and public information; registration by equivalence; comparative risk assessment and the substitution principle. The Panel **recommended** to extend the commenting period until 31 December 2008, after

which a new draft should prepared and circulated among Panel members for endorsement, no later than March 2009. The Panel **requested** that, if no major comments are received, FAO and WHO, after formatting and editing, proceed with publication of the guideline.

c) With respect to the *Guidelines on Pesticide Advertising*, the Panel took note of the new draft which had been prepared by the Task Group chair and the comments provided on this document. The Panel **recommended** that the provisions of Article 11 in the Code would need to apply to all forms of advertising. The Panel further discussed the issue of inappropriate incentives and **concluded** that a list of examples should be provided in the guideline, taking into account the comments made. The Panel **recommended** that the Task Group prepare a new draft of the document by January 2009, for subsequent circulation by among the Panel members for endorsement. The Panel **requested** that, if no major comments are received, FAO and WHO, after formatting and editing, proceed with publication of the guideline no later than June 2009.

17. The Panel reviewed a number of draft guidelines which had been proposed for updating, and made the following recommendations.

a) With respect to *Guidelines on Pesticide Legislation*, the Panel took note of the *FAO Legislative Study on Designing National Pesticide Legislation* and **commended** its quality. The Panel **underlined** that existing FAO guidelines on pesticide legislation are outdated and do not cover all pesticide uses addressed in the Code of Conduct. The Panel discussed in which ways the study could be used as a basis for the elaboration of a new guideline on pesticide legislation, covering all areas of pesticide use, including public health and domestic uses. The Panel **recommended** that FAO and WHO initiate the development of an outline for a new guideline on pesticide legislation, to be presented for consideration by the Panel at its next session.

b) With respect to the Guidelines *on Good Labelling Practice for Pesticides*, the Panel took note of the status of updating this document. The Panel **stressed** the importance of effective labelling of pesticides as a prime tool for communication with the user. The Panel **agreed** that clear advice on labelling needs to be provided to countries, and that parallel presentations of the WHO and GHS classifications for pesticides in the same guideline should be avoided. The Panel **recommended** that the guideline be updated, taking into account the GHS but ensuring that the existing guideline is not changed more than absolutely necessary, and that a first draft be circulated among Panel members and observers by January 2009.

Review of Code of Conduct

18. The Panel discussed the scope and objectives of the *International Code of Conduct on the Distribution and Use of Pesticides* and **noted** that, while these clearly address all pesticides, the provisions of the Code of Conduct and the included references appear to lean to the management of agricultural pesticides. The Panel therefore **recommended** that FAO and WHO start the process to ensure that the Code of Conduct, and its

implementation tools, adequately addresses all pesticides, and in particular public health pesticides.

16. Closure of the meeting

The 2nd FAO/WHO Joint Meeting on Pesticide Management, and the 4th Session of the FAO Panel of Experts on Pesticide Management, was closed by Mr Mark Davis, Senior Officer a.i. of the Pesticide Management Group of FAO and by Dr Morteza Zaim, Scientist in charge of the WHO Pesticide Evaluation Scheme. They thanked all participants for their valuable inputs in the discussions and expressed their satisfaction about the progress that was made.

The meeting was informed that Dr Vibeke Bernson, who had chaired the meeting over the last few years, would be retiring at the end of 2008. Her pleasant but very efficient way of chairing the meetings has greatly contributed to their success. Her contribution to the Panel was gratefully acknowledged.

Finally, the meeting also took note of the fact that FAO Panel members will come to the end of their 4-year term in the course of 2009, but before the next session. Therefore, Mr Davis extended his sincere gratitude, on behalf of FAO, to all for having accepted to sit on the Panel and for having shared their experience and expertise. He presented an FAO memorial medal to each FAO Panel member as an expression of the appreciation of the Organization.

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Annex 2 – Agenda

1. Opening of the meeting and welcome address

2. Appointment of Chairman and Rapporteurs

3. Adoption of agenda

4. Introduction of meeting procedure, working arrangements and housekeeping matters.

5. Summary of developments and actions taken after the first joint meeting in October 2007.

6. Highly hazardous pesticides – status of implementation of recommendations made after the first joint meeting in October 2007.

7. Draft Guidelines agreed for publication in the previous meeting – status report
   a. Guidelines on management options for empty pesticide containers.
   b. Guidelines on pesticide advertising.
   c. Guidance on pest and pesticide management policy development – agriculture.

8. Draft Guidelines under development – status report
   a. Guidelines on resistance management for pesticides.
   b. Guidelines on registration microbial pest control agents.

9. Draft outlines for Guidelines – for review
   a. Guidelines on retail establishments of pesticides.

10. Draft Guidelines – for review.
    a. Guidelines on the development a reporting system for health and environmental incidents resulting from exposure to pesticides.
    b. Guidelines on registration of pesticides.

11. Guidelines proposed for updating – issues regarding content
    a. Guidelines on pesticide legislation
    b. Guidelines on good labelling practice for pesticides

12. Implementation of the revised version of the International Code of Conduct – future orientation of activities.

13. Any other matters.

Hazards of pesticides imported into Mozambique, 2002-2011

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Roel Kruijne
Jan Groenwold

This research was funded by the United nations Food and Agriculture Organization (FAO) under projects 'Reducing Risks of Highly Hazardous Pesticides in Mozambique' (EP/MOZ/101/EUP) and 'Disposal of Persistent Organic Pesticides and Obsolete Stocks in Mozambique' (GCP/MOZ/100/GTF).

Alterra Wageningen UR
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Keywords: pesticides, Mozambique, import data, human health hazard, environmental hazard

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Contents

Summary

Together with the government of Mozambique, The Food and Agriculture of the United Nations (FAO) is implementing a project to identify the most Highly Hazardous Pesticides (HHPs) in Mozambique based on import data and to reduce risks of these pesticides by recommendations for mitigation measures. In the framework of this project Alterra, Wageningen UR, has conducted a desk top study to assess the hazards associated with pesticides imported in Mozambique from 2002 to 2011. The objectives of the study were (1) to conduct an evaluation of historical trends in the use of pesticides in Mozambique based on pesticide import data compiled by the Ministry of Agriculture over the period 2002 – 2011, (2) to assess trends in human health and environmental hazards and potential risks of the pesticides imported in Mozambique, and (3) to identify pesticides or pesticide use patterns (as far as feasible) contributing most to these hazards.

In order to analyse trends in potential hazards of pesticide use on human health and the environment, hazard based indicators were used for occupational health, aquatic organisms, bees and groundwater. When true exposure assessment data are not available, hazard based indicators can be used to rank pesticides relatively to each other from high to low hazard. FAO supplied data to Alterra of pesticides imported into Mozambique from the years 2002 to 2011, as well as information on pesticides with a registration in Mozambique. It is not clear if the pesticide import data for 2002 used in this study are complete.

The most important results of the study are:

- The volume of pesticides imported increased almost threefold, from 670 tonnes in 2003 to 2592 tonnes in 2011. Agricultural production increased by 40 % from 9.9 million tonnes in 2002 to 13,9 million tonnes in 2011, whereas the agricultural area increased only by 1.4%;
- The types of pesticides imported in the country are very consistent over time. The majority of products consists of insecticides, followed by the herbicides and fungicides;
- The volume of highly hazardous products imported over time decreased and the volume of products with a (very) low hazard increased;
- Only few pesticide products with a known chronic hazard to human health were imported in the country, although carcinogenic products were imported at the rate of 100 tons per year;
- A considerable number of the pesticides imported into the country are acutely toxic to fish, aquatic invertebrates, algae and bees. However, the less hazardous pesticides represent a much higher volume of imports;
- The Environmental Toxic Load (ETL) (relative hazard corrected for surface of agricultural area) to aquatic organisms (fish, aquatic invertebrates and algae) increases from 2002 to 2010, but decreases for all three groups of species in 2011;
- Overall, the hazard of the imported pesticides is more than two times higher to aquatic invertebrates and algae than to fish;
- The ETL to bees also increases from 2002 to 2008, but is considerably lower from 2009 to 2011;
- Only few active ingredients with a very high or high leaching potential are imported in the country.

The pesticides that contributed most to the overall human health hazards and environmental hazards are given in the following table. Active ingredients of primary or secondary concern were identified using criteria that combine both potential hazard of the pesticides and imported quantities in Mozambique. The table may be used to focus hazard reducing measures in the country.

Pesticides imported in Mozambique from 2002 to 2011 that are of concern in terms of potential human health and environmental hazard and annually imported quantity.

Type of hazard	Pesticide active ingredient of primary concern	Pesticide active ingredient of secondary concern
Human health		
Acute (WHO classification)	Class I pesticide products containing: Abamectin Aldicarb Aluminium phoshide Fenamiphos Methomyl Mevinphos Monocrotophos Oxamyl Terbufos	Class II pesticide products containing: Ametryn DDT Lambda-cyhalothrin
Chronic	Diuron (carcinogenic) Mancozeb (carcinogenic)	Dichlorvos (carcinogenic)
Environment		
Fish	Lambda-cyhalothrin	Aluminium phoshide Chlorpyrifos Cyfluthrin Cypermethrin Endosulfan
Aquatic invertebrates	-	Chlorpyrifos Cypermethrin DDT Dichlorvos Ethion Fenvalerate Lambda-cyhalothrin Pirimiphos-methyl
Algae	Acetochlor	Ametryn Paraquat
Bees	Imidacloprid	Bendiocarb Chlorpyrifos Cyfluthrin Cypermethrin Deltamethrin Lambda-cyhalothrin Profenofos Thiamethoxam
Leaching to groundwater	Methyl bromide Tebuthiuron	Atrazine Clomazone Hexazione Imidacloprid Propoxur

1 Introduction

1.1 Scope of the project

Together with the government of Mozambique, The Food and Agriculture of the United Nations (FAO) has been implementaing a project to identify the most Highly Hazardous Pesticides (HHPs) in Mozambique and to reduce risks of these pesticides by recommendations for mitigation measures.

In the framework of this project Alterra, Wageningen UR, has conducted a desk top study of the hazards associated with pesticides imported in Mozambique from 2002 to 2011.

1.2 Objectives

The objectives of the study were:

1. to conduct an evaluation of historical trends in the use of pesticides in Mozambique based on pesticide import data compiled by the Ministry of Agriculture over the period 2002 – 2011,
2. to assess trends in human health and environmental hazards and potential risks of the pesticides imported in Mozambique, and
3. to identify pesticides or pesticide use patterns (as far as feasible) contributing most to these hazards.

1.3 Approach

The potential risk related to the use of a specific pesticide is always determined by pesticide properties (hazard) and circumstances in which the pesticide is used (exposure). Therefore:

Risk = hazard × exposure

Hazard is determined by the toxicological properties of the pesticide. Environmental exposure is determined by pesticide use patterns, the physico-chemical properties of the active ingredient (a.i.) and the properties of the environment (e.g. soil, climate, surface water) of concern. Human occupational exposure is further determined by use of personal protective equipment, application equipment, skills and awareness of the operator, while dietary exposure is determined by many other factors like for instance composition of diet.

In order to analyse trends in potential hazards of pesticide use on human health and the environment, we used hazard based indicators for occupational health, aquatic organisms, bees and groundwater. When real exposure assessment data are not available, hazard based indicators can be used to rank pesticides relatively to each other from high to low hazard. These indicators, together with the quantitative information on pesticides use, can provide an indication of which pesticides are most likely to pose a potential problem. Such an approach has earlier been successful in identifying the trends in the hazards of pesticides used in cotton in different countries (De Blécourt et al., 2010). The actual risks posed by these pesticides, however, remain uncertain as realistic exposure profiles are not explicitly taken into consideration. This would need more location-specific data. But while perhaps less specific than risk indicators due to the lack of exposure data, hazard indicators are quite suitable for trend assessments and ranking exercises.

2 Methods

2.1 Datasets

FAO has supplied data to Alterra of pesticides imported into Mozambique from the years 2002 to 2011, as well as information on pesticides with a registration in Mozambique. Hereafter these spreadsheet files will be referred to as the Import data and the Registered pesticide data, respectively. Following an initial quality check conducted by Alterra, additional efforts by FAO and Alterra were needed in order to enhance the quality of these data, notably the Import data.

2.1.1 Import data

Text fields in the original Excel spreadsheet with Import data delivered by FAO contain Product names, Active ingredient names, Categories (i.e. the product group), Importer names, Units of Concentration, Units of Quantity, and the Monetary Units. These text fields were screened for typing errors, alternative spelling, abbreviations, etc.

Inconsistent entries were corrected when possible. Those which could not be corrected were removed from the dataset. For example, the active ingredient content is required for conversion of product volumes into active ingredient volumes. The import data included 11 bio pesticides and inorganic pesticides with an unknown formulation (i.e. a blank) or a value out of range in the content field. These import events had to be removed. In another five cases, a missing value for the content was replaced with the mean value of the content in the other imported products with exactly the same active ingredients. A numerical field was added to the text fields for identification. In some cases the number in the Concentration a.i. field was corrected in order to obtain a unique value for the content of the active ingredient of a formulated product

2.1.2 Pesticide properties

In order to make an analysis of the human and environmental hazards related to the agricultural use of pesticides in Mozambique, full consistency is required between the product formulation in the Import data and the active ingredients in the Registered pesticide data. On a few occasions, when the information in both datasets did not entirely match, we let the Import data prevail over the Registered pesticide data.

We gathered the toxicity and fate properties of the active ingredients and the products mentioned in the Import data from the following sources:

1. The Registered pesticide data, mainly for human toxicity data.
2. The internal compound database of the Alterra team Ecological Risk Assessment (ERA). This internal database is used for projects only and was last updated for the study on cotton (see De Blécourt *et al.*, 2010).
3. A compound database available from the evaluation of the Dutch policy plan for sustainable use of pesticides (mainly for fate properties).
4. The Pesticides Properties DataBase PPDB (Footprint; 2013, 2007) database, for the classification of physical properties and environmental toxicity.

Some 80% of the properties required for the analysis were found in these sources. We used a routine for the repacement of missing values for compound properties, which consists of the following steps:

- When a parameter value for an active ingredient is not available, the mean value of all active ingredients from the same chemical class will be used (e.g., carbamate, organophosphate).

- When the mean of the parameter values for the active ingredients from the same chemical class cannot be calculated, the mean of all active ingredients from the same product group is used (insecticides, fungicides, etc.).
- When no mean values can be calculated, the parameter value is classified as unknown.

Accordingly, the status of each property will be either 1) original value, 2) estimated value based on chemical class, 3) estimated value based on product group, or 4) not available. This routine was developed in the framework of the European HAIR project on risk indicators for agricultural use of pesticides (Kruijne *et al.*, 2011). It was developed and approved by the scientists in the HAIR consortium, but is has so far not been validated.

Annex 1 contains the fate properties and toxicity values for all active ingredients, including the source.

2.2 Trends in pesticide import

Trends in pesticide import in Mozambique from 2002 to 2011 were explored in terms of numbers (type) of pesticides and volume (amount) of pesticides. Trends in imported pesticide products and their active ingredients were based on the annual volume imported and the formulation of these products. Metabolites are not considered in this study.

In reality, the annual volume of products used in agricultural crops in the country may be different from the volume imported due to changes in stocks, exports to other countries, and non-agricultural uses. Gathering information on these flows and stocks was beyond the scope of this study. Moreover, the Import data or Registered pesticide data did not contain information on their use in e.g. agriculture, public health or veterinary use, so no formal distinction can be made. The import data provided are regarded as a proxy for actual use in Mozambique in the different sectors combined.

2.3 Hazard indicators

Hazard based indicators were used to rank products and active ingredients relative to each other from high to low hazard. Hazard is defined by the OECD (2003) as 'an inherent property of an agent or situation having the potential to cause adverse effects when an organism, system or (sub) population is exposed to that agent'. Hazard is determined by the toxicological properties of the formulated pesticide or its active ingredients. The hazard assessments conducted in this study do not estimate the actual risks in the field since true risks depend on many more factors that are not explicitly taken into account here such as pesticide formulation, soil properties, weather conditions during application, use of protective personal equipment, method of application, buffer strips and other mitigation techniques, the species that do actually occur in the field, etc.

In this study hazard assessments were performed for: 1) acute hazard to human health (WHO hazard classification), 2) chronic hazard to human health (carcinogenicity, mutagenicity and effects on reproduction), 3) hazard to aquatic organisms (fish, *Daphnia,* and algae), 4) hazard to bees, and 5) groundwater leaching potential. The basis of the indicators is described more fully below.

2.3.1 Acute hazard to human health

The classification of active ingredients according to their acute toxicity to human health originated from 'The World Health Organization recommended classification of pesticides by Hazard' (WHO, 2010). The hazard referred to is the acute hazard to health (that is, the potential effects of single or multiple exposures over a relatively short period of time) that might be encountered accidentally by any person handling the product in accordance with the directions for handling by the manufacturer or in accordance with the rules laid down for storage and transportation by competent international bodies. This definition does not include the regular handling of products in developing countries without personal protection equipment and consequent exposure.

The classification is primarily based on data on the acute oral and dermal toxicity to rats as standard testing species. Since 2009 it does not distinguish anymore between solid and liquid formulations. Provision is made for the classification of a particular compound to be adjusted if, for any reasons, the acute hazard to man differs from that indicated by the LD50 assessments alone. The WHO classification takes into consideration the toxicity of the technical compound and its common formulations. The criteria for classification are shown in Table 1.

Table 1: Categories of acute toxicity to human health according to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) used for classification of formulations (WHO, 2010).

WHO Class		$LD50_P$ (mg/kg body weight)	
		Oral	Dermal
Ia	Extremely hazardous	< 5	< 50
Ib	Highly hazardous	5-50	50-200
II	Moderately hazardous	50-2000	200-2000
III	Slightly hazardous	2000-5000	2000-5000
U	Unlikely to present acute hazard	5000 or higher	

The classification of any product depends on the formulation concentration. If the concentration of the formulation is low, this may decrease the exposure and thus the acute risk (Equations 1, 2). Furthermore, for a solid formulation the exposure is usually lower compared to a liquid formulation since it is more difficult for a solid to pass through the skin.

Products containing a single active ingredient are classified based on the proportional toxicity and the categories shown in Table 1.

$$LD50_P = \frac{LD50_{ai}}{f_{ai}} \qquad \text{Eq. 1}$$

$LD50_P$ proportional LD50 for the product formulation (mg/kg body weight)
$LD50_{ai}$ oral acute LD50 or dermal acute LD50 of the active ingredient (mg/kg body weight)
f_{ai} content of the active ingredient (fraction)

Mixtures, i.e. products containing multiple active ingredients, are classified according to

$$LD50_P = \frac{1}{\sum \frac{f_{ai}}{LD50_{ai}}} \qquad \text{Eq. 2}$$

using the categories for oral toxicity shown in Table 1.

According to the WHO (2010), if both the oral acute LD50 and the dermal acute LD50 are available, the product should be classified based on the acute toxicity which results in the highest hazard class. The fields used for LD50 values in the Registered pesticide data were not entirely internally consistent. Fields contained numbers with both decimal points and comma's, text characters instead of numbers, combinations of both, lower limits, ranges, blanks and colours. This was too cumbersome to straighten out for 200 active ingredients in some 450 products. Numerical toxicity data were therefore partly gathered from the other sources used (see Annex 1). For practical reasons we decided only to use oral toxicity data. Oral LD50 data were more suitable to deal with the classification of mixtures. Often, there were no dermal data for all active ingredients in a mixture. Formulated mixtures of pesticides

cannot be classified on combined oral and dermal data (WHO, 2010). Moreover, the availability of dermal toxicity data is limited compared to oral toxicity, a fact that is recognised by the WHO (2010).

The consequence is that the oral toxicity criteria for classes Ia, Ib and II are slightly less strict than for purely dermal data. But oral toxicity is often higher than dermal toxicity, so in the majority of cases the use of oral toxicity data will lead to the most conservative classification. Another advantage is that all formulated pesticides are classified in a uniform way.

2.3.2 Chronic hazard to human health

According to the explanation provided with the HHP data, the classification of active ingredients of pesticides according to their chronic hazard to human health considering carcinogenicity, mutagenicity and reproductive toxicity according to the HHP data originated from at least four different sources including three different classification systems: the Globally Harmonized System (GHS) criteria, the classification system according to Directive 67/548/EEC and the US-EPA classification on carcinogenicity. The four different sources were needed in order to gather hazard classifications for as many active ingredients as possible:

- the active ingredient has been considered to be classified as a carcinogen of category 1A or 1B according to the GHS, a mutagen or reprotoxic ("yes"),
- the active ingredient is not classified as such ("no"), or
- the active ingredient was not evaluated by these sources ("n.e.").

For this study we classified chronic hazard to human health according to the following decision rules:

- "yes" in case the active ingredient is toxic according to at least one of the sources mentioned,
- "no" in case the active ingredient is not qualified as toxic according to any of the sources and the active ingredient is qualified "not toxic" according to at least one of the sources.
- "n.e." in case the active ingredient is neither toxic nor "not toxic" according to all sources.

2.3.3 Acute environmental hazard

The parameter used to classify the acute toxicity of active ingredients of pesticides to algae is the concentration that causes a 50% reduction in growth rate or final yield (EC50) of the test organisms in a standard algae test (usually 72h). The acute toxicity of pesticides to fish and the water flea *Daphnia* (representing aquatic invertebrates) is also expressed as acute EC50 or LC50 values (an LC50 is the concentration that kills 50% of the test organisms). The classification criteria of active ingredients according to acute toxicity to aquatic organisms is listed in Table 2. The classification was established by the US-EPA: http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm (retrieved in July 2009).

Table 2: Categories of acute toxicity to aquatic organisms (according to EPA, 2009)

LC50 or EC50 (mg/L)	Acute hazard to aquatic organisms
< 0.1	Very highly toxic
0.1 - 1	Highly toxic
1 - 10	Moderately toxic
10 - 100	Slightly toxic
> 100	Practically nontoxic

The classification of active ingredients according to their acute toxicity to bees is based on the dose per bee that kills 50% of bees (orally or by contact). The criteria for this classification are provided in Table 3. The classification originates from the 'Manual for summarizing and evaluating the environmental aspects of plant protection products' published by the Dutch National Institute for Public Health and the Environment (Mensink et al., 1995).

Table 3: Categories of acute toxicity to bees (Mensink et al., 1995)

LD50 (µg/bee)	Hazard to bees
< 0.1	Highly toxic
0.1 - 1	Toxic
1 - 10	Moderately toxic
10 - 100	Slightly toxic
> 100	Very slightly toxic

2.3.4 Environmental Toxic Load

The Environmental Toxic Load (ETL) indicator represents the average amount of toxic pressure by active ingredients of pesticides applied on one hectare of agricultural land in one year. Toxicity is mediated by the fact that only a small proportion of the pesticide volume will reach the organism. Dissipation processes like degradation and sorption are not taken into account. A similar approach has been used by Benbrook et al. (2002) and De Blécourt et al., 2010.

The ETL indicator is calculated separately for fish, *Daphnia*, algae and bees. The ETL is based on the total imported volume of active ingredients per year, the toxicity (either L(E)C50 for algae, *Daphnia* or fish or the LD50 for bees), and the total agricultural area in Mozambique. It is calculated as:

$$ETL_{yr} = \frac{\sum_{ai} \frac{V_{ai,yr}}{T_{ai}}}{A_{yr}} \qquad \text{Eq. 3}$$

ETL_{yr} Environmental Toxic Load indicator value for one year
$V_{ai,\,yr}$ volume of an active ingredient imported in a particular year (kg)
T_{ai} toxicity of the active ingredient; i.e. L(E)C50 of either fish, *Daphnia* or algae (mg/L), or the LD50 of bees (µg/bee)
A_{yr} total agricultural area in Mozambique in a particular year (ha)

The ETL cannot be used to assess the actual risk (i.e., the probability of an adverse effect on organisms) as a consequence of pesticide treatments because there is no exposure assessment involved in its calculation. For instance there is no prediction of an environmental concentration (PEC) in water that can be compared with a 'no effect concentration' for water organisms (PEC/NEC analysis). There is no thresholds of the ETL that signifies an absolute risk.

The ETL can therefore only be used to evaluate the impact of changes in relative environmental hazards between pesticides and between years. Furthermore, since toxicity data for bees (LD50) are expressed on the basis of µg/bee the ETL for bees cannot be compared to the ETL values for the aquatic organisms for which the toxicity (LC50 or EC50) is expressed in mg/L. However, since the same units for toxicity are used for algae, *Daphnia* and fish, it is justified to compare ETL's between these aquatic organisms. For instance it is possible to indicate if the pesticide import in Mozambique in a given year poses a higher overall potential hazard to algae than to fish. If the ETL for algae equals 10 and the ETL for fish equals 1000 in a certain year, the overall hazard of the pesticide import in Mozambique is 100 times greater for fish than for algae.

2.3.5 Groundwater leaching potential

The Groundwater Ubiquity Score or GUS (Gustafson, 1989) is an indication of the potential of the active ingredient of a pesticide to reach the groundwater before it is degraded. The GUS is an empirically derived value that relates to the persistence and sorption to soil organic matter of the active ingredient. The GUS index is calculated as follows

$$GUS = \log(DegT50_{soil}) \cdot (4 - \log K_{OC}) \qquad \text{Eq. 4}$$

GUS	potential of an active ingredient to reach the groundwater (-)
$DegT50_{soil}$	degradation half-life in soil (d)
K_{OC}	organic carbon sorption coefficient (L/kg).

The pesticide leaching potential is derived from the GUS. The ratings of active ingredients of pesticides range from very low to very high. The criteria are set out in Table 4.

Table 4: categories of groundwater leaching potential based on the GUS index.

GUS	Class	Groundwater leaching potential
< 1.0	1	Very low
1.0 – 2.0	2	Low
2.0 – 3.0	3	Moderate
3.0 – 4.0	4	High
> 4.0	5	Very high

2.4 Pesticides of concern

After the indicators were calculated and the analyses were done, criteria were established to select pesticides of concern. These are the pesticides that represent both an high hazard to human health and/or to the environment and that are imported in relatively large quantities in Mozambique for several years. The aim of this classification is to identify those pesticides and pesticide products for which the biggest gain in terms of reducing overall hazard to human health and/or the environment can be achieved by measures such as reducing their use in the country.

We distinguish two categories: 1) pesticides of primary concern, i.e., pesticides that contribute to a very large extent to the indicator values and that really stand out, and 2) pesticides of secondary concern that also contribute significantly but in a less dominant way. Both categories of pesticides are suitable to realise reductions of overall hazards by specific measures.

The criteria are applied per indicator or per group of indicators. This means that the pesticides of concern only stand out against other pesticides for a particular hazard. The overall hazard of imported hazards may be much bigger for, say, aquatic organisms than for human health, but such comparisons cannot be made based on the type of indicators that were used.

The criteria that were applied are listed on the following page.

Acute human health hazard (WHO classification of formulated products)

Primary concern:	All active ingredients occurring in WHO Class I formulated products imported from 2002 to 2011.
Secondary concern:	Active ingredients occurring in WHO Class II formulated products of which the imported volume (of formulated products) constitutes >5% of the total annually imported volume in 2 years or more.

Chronic human health

Primary concern:	Carcinogenic, mutagenic or reprotoxic active ingredients of which the imported quantity of a.i. constitutes >5% of the total quantity of annually imported a.i. in 2 years or more.
Secondary concern:	Carcinogenic, mutagenic or reprotoxic active ingredients of which the imported quantity of a.i. constitutes >1% of the total quantity of annually imported a.i. in 1 year or more.

Environmental Toxic Loads (fish, aquatic invertebrates, algae, bees)

Primary concern:	Active ingredients of which the imported quantity of a.i. constitutes >50% of the total annual ETL value in 2 years or more.
Secondary concern:	Active ingredients of which the imported quantity of a.i. constitutes >10% of the total annual ETL value in 1 year or more.

Groundwater Ubiquity Score (GUS)

Primary concern:	GUS class 5 active ingredients of which the imported quantity of a.i. constitutes >1% of the annual GUS index value in 2 years or more. And/or GUS class 4 active ingredients of which the imported quantity of a.i. constitutes >2% of the annual GUS index value in 2 year or more.
Secondary concern:	GUS class 5 active ingredients of which the imported quantity of a.i. constitutes >0.5% of the annual GUS index value in 1 year or more. and/or GUS class 4 active ingredients of which the imported quantity of a.i. constitutes >1% of the annual GUS index value in 1 year or more.

3 Results

3.1 Agricultural statistics

The dynamics in the total agricultural area in Mozambique according to FAOSTAT data (http://faostat3.fao.org/; accessed on July 1, 2013) are shown in Figure 1. The total agricultural area increased with 1,4% during the study period (2002-2011), i.e., from 48,7 million ha in 2002 to 49,4 million ha in 2011.

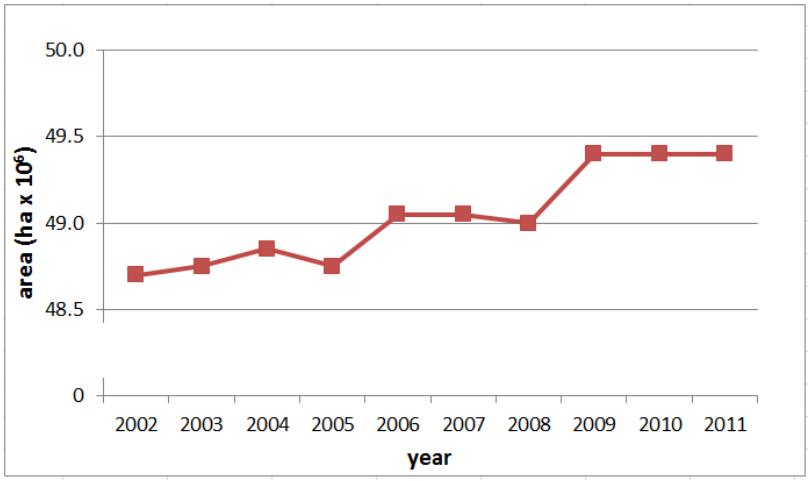

Figure 1: Total agricultural area in Mozambique in the years 2002 – 2011 (http://faostat3.fao.org/).

The total agricultural production according to FAOSTAT data (http://faostat3.fao.org/; July 1, 2013) is shown in Figure 2. These figures were calculated as the sum of eleven aggregated items[1]. The total agricultural production increased with 40% from 9,9 million tonnes in 2002 to 13,9 million tonnes in 2011. Because the cultivated area in the country did hardly increase over this period, it can be concluded that agriculture in Mozambique must have considerably intensified during this period.

[1] Cereals, Total; Citrus Fruit, Total; Coarse Grain, Total; Fibre Crops Primary; Fruit excl Melons, Total; Jute & Jute-like Fibres; Oilcrops Primary; Pulses, Total; Roots and Tubers, Total; Treenuts, Total; and Vegetables Primary.

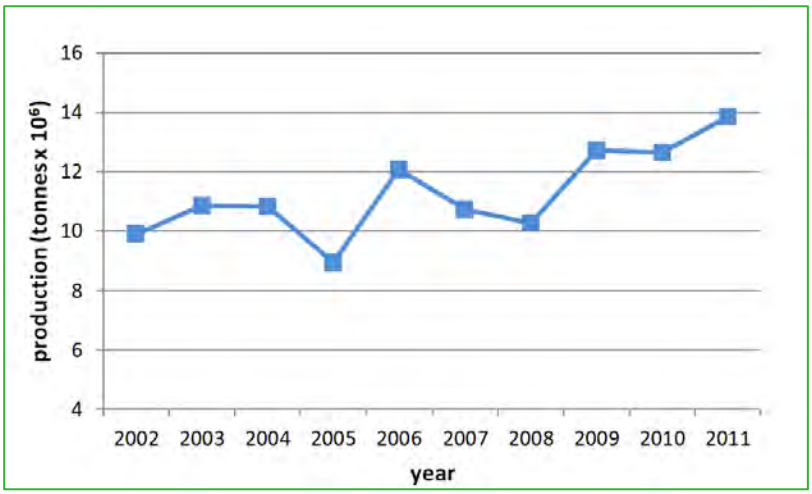

Figure 2: The total agricultural production in Mozambique in the years 2002 – 2011 (http://faostat3.fao.org/).

3.2 Pesticide imports

This section provides insights into trends in pesticide imports into Mozambique from 2002 to 2011. Trends are shown in the annual numbers and types (Section 3.2.1), the volume (Section 3.2.2) and the monetary value of imported pesticides (Section 3.2.3). In addition, the volume and the monetary value of imported pesticides are presented per unit of agricultural land and per unit weight of harvested product.

The Import data contain a relatively small number of import events for the first year, 2002. It seems logical that the dataset for this year is incomplete, but the authors have not received a confirmation of this. Since we cannot be entirely sure that the data of 2002 are representative for the entire year, we have decided to include the year 2002 in the graphs and tables but not to discuss the results for this particular year each time indicator values are lower compared to the other years.

3.2.1 Imported numbers of pesticides

Products

The annual number of formulated pesticide products imported is shown in Figure 3. The number fluctuates slightly and increases from 115 in the year 2003 to 157 in the year 2011.

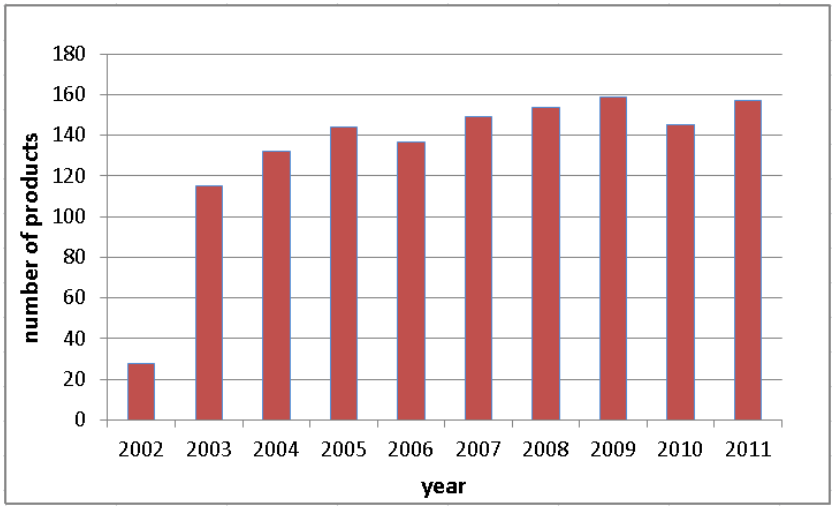

Figure 3: The annual number of formulated pesticide products imported in the years 2002 – 2011.

Product groups

The distribution of formulated pesticide products among the eight functional pesticide groups is shown in Figure 4. Insecticides constitute the major product group in all years, followed by herbicides and fungicides.

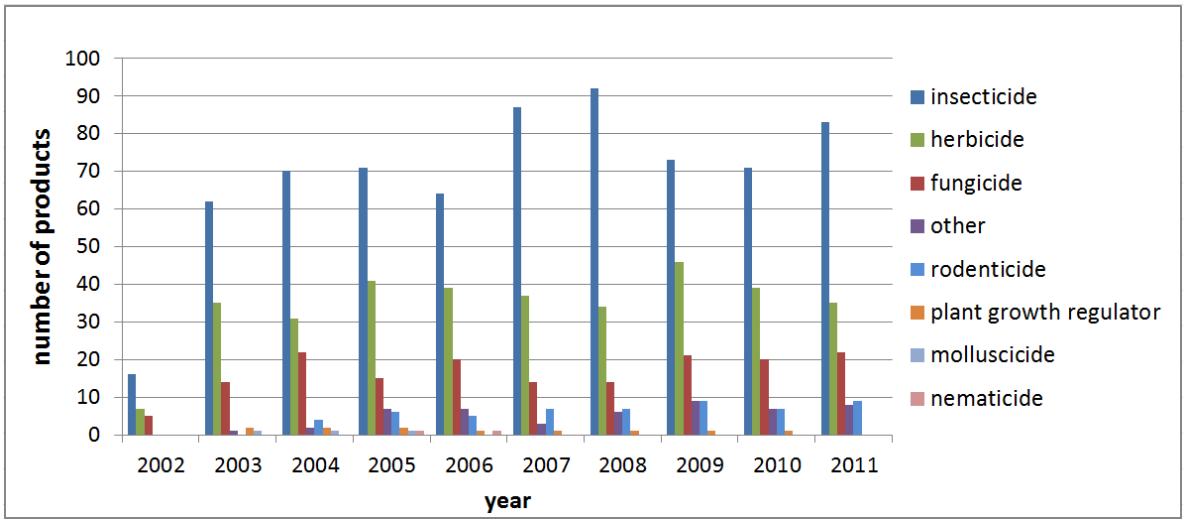

Figure 4: The number of formulated pesticide products per functional pesticide group imported yearly from 2002 to 2011.

Active ingredients

The formulated pesticide products imported in the period 2002-2011 contain 175 active ingredients assigned to 72 different chemical classes. The chemical classes with the largest number of active ingredients are the organophosphates (19 active ingredients), pyrethroids (16), carbamates (9), inorganic compounds (9), biopesticides (8), unclassified compounds (8), triazines (8) and triazoles (6). The annual number of chemical classes of active ingredients in the imported pesticides is shown in Figure 5. The numbers of the types of pesticides imported in the country increased up to 2005 and the fluctuated between c. 45 and 55.

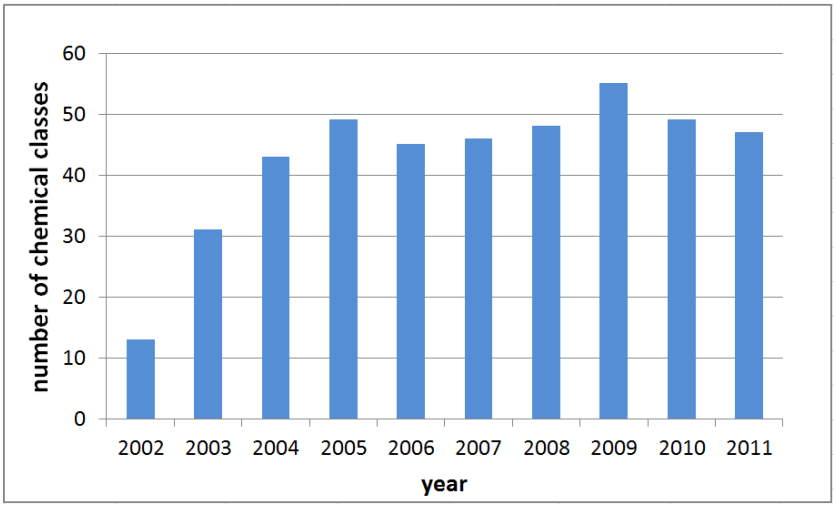

Figure 5: The number of chemical classes of the active ingredients imported annually in the years 2002 – 2011.

Importers

The annual number of active pesticide importers in Mozambique is shown in Figure 6. The numbers increase from 2002 to 2004, but decline in 2005 and 2006. From 2007 onwards the number increases again and the maximum number of importers is reached in the year 2010. Forty-four different importers were identified based on the Import data. The number of imported pesticide products per major importer is shown in Figure 7.

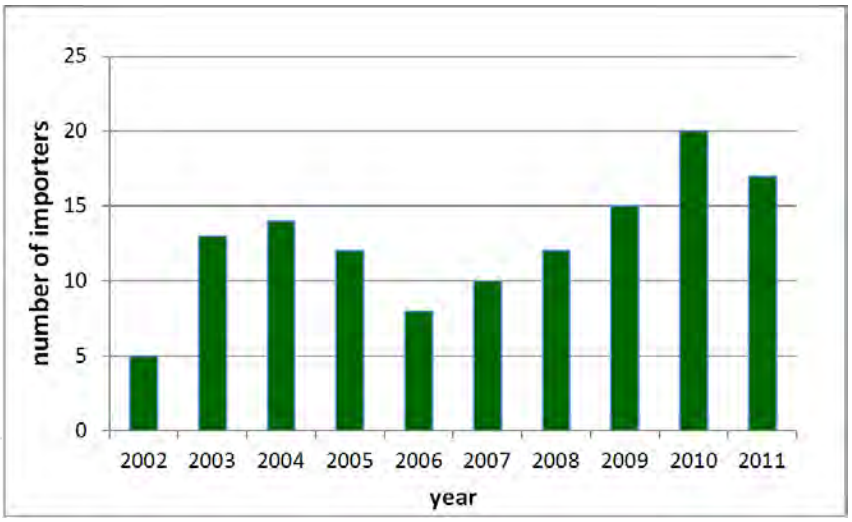

Figure 6: The number of pesticide importers responsible for the yearly imports from 2002 to 2011.

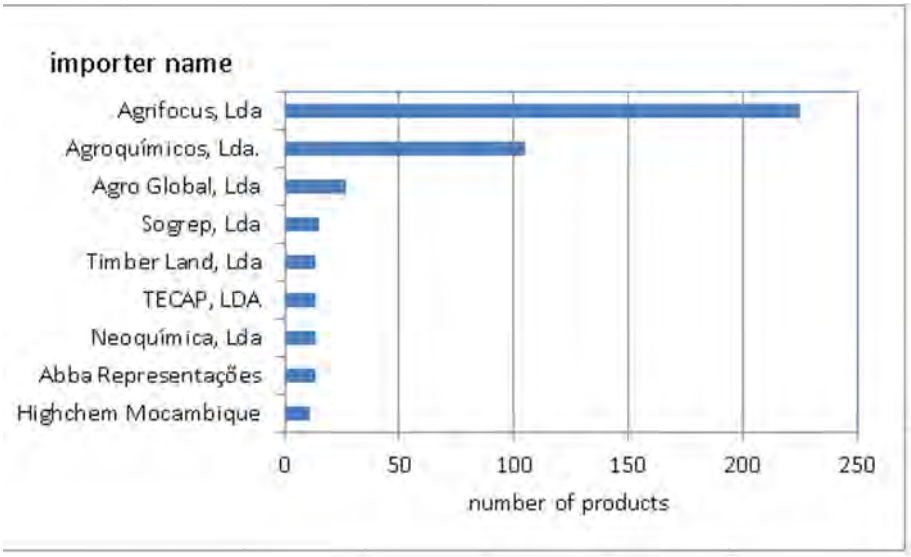

Figure 7: The total number of products imported by the major importers in the period 2002-2011.

3.2.2 Imported pesticide volume

Products

The annual volume of imported pesticides is shown in Figure 8. The imported volume increases until the year 2006. In the next year, 2007, the volume decreases by 37% to 1278 tonnes. As from 2008, the volume increases again to 2592 tonnes in the year 2011.

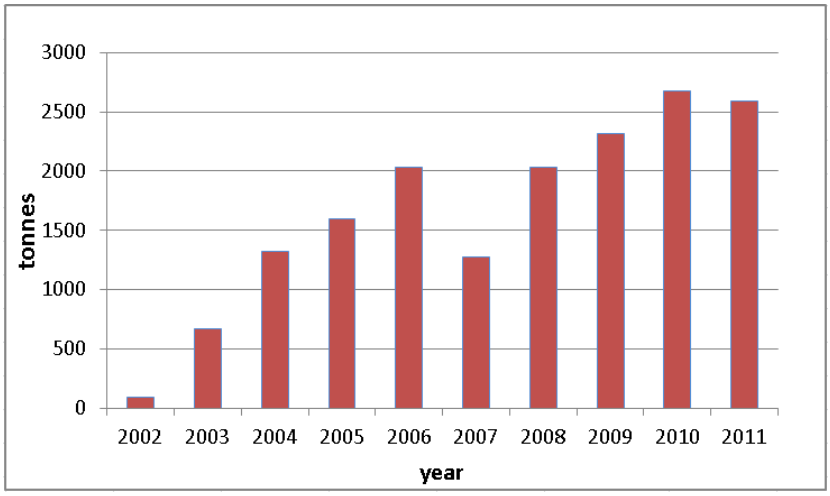

Figure 8: The annual volume of imported pesticide products in the years 2002 – 2011 (tonnes).

The volume of imported pesticides corrected for the total agricultural area (Figure 1) is shown in Figure 9, expressed in kg pesticides per hectare agricultural land. Because the total cultivated area changed only little during the study period, the pattern in Figure 9 is the same as in Figure 8.

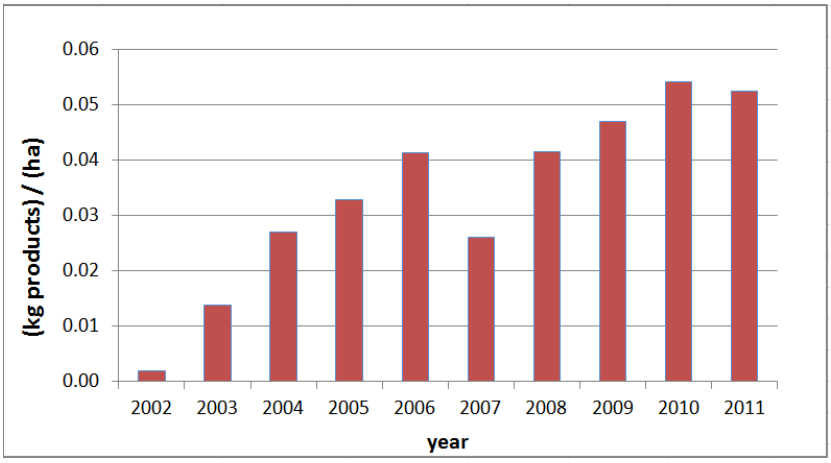

Figure 9: The annual volume of imported products corrected for the total agricultural area in the years 2002 – 2011 (kg/ha).

The volume of imported pesticides corrected for the total agricultural production (Figure 2) is shown in Figure 10. In the year 2007, the corrected volume of imported products decreases with 29% to 0.12 kg per ton harvested products. The figure clearly shows that although the total pesticide import per hectare in Mozambique is increasing (Figure 9), the pesticide import per tonne of harvested produce has been more or less constant from 2008 to 2011.

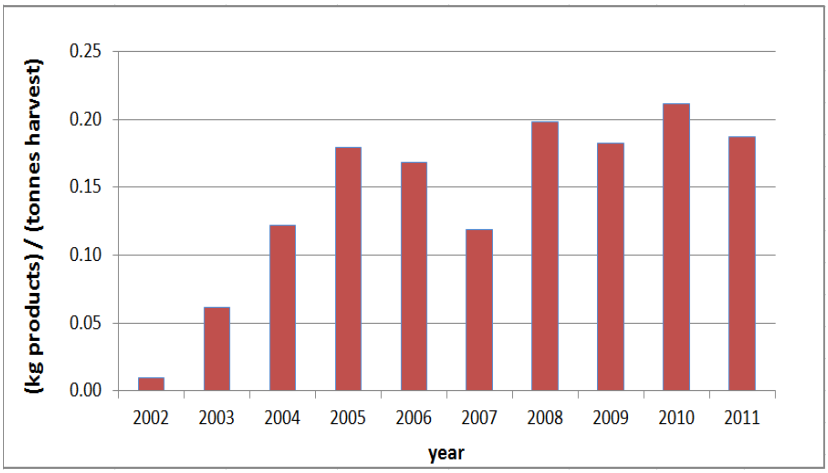

Figure 10: The annual volume of imported products corrected for the total agricultural production in the years 2002 – 2011 (kg products imported per ton of harvested products).

Product groups

The annual volume of imported products belonging to the eight functional groups is shown in Figure 11. Insecticides and herbicides constitute the major groups, followed by fungicides. The total amount of imported formulated pesticides increases in the first half of the decade and shows a dip in 2007. From 2008 to 2011 it is approximately the same. The annual volumes of insecticides and herbicides are more or less equal except in the years 2006 and 2008. In these two years, the volume of insecticides exceeds the volume of herbicides by some 50%.

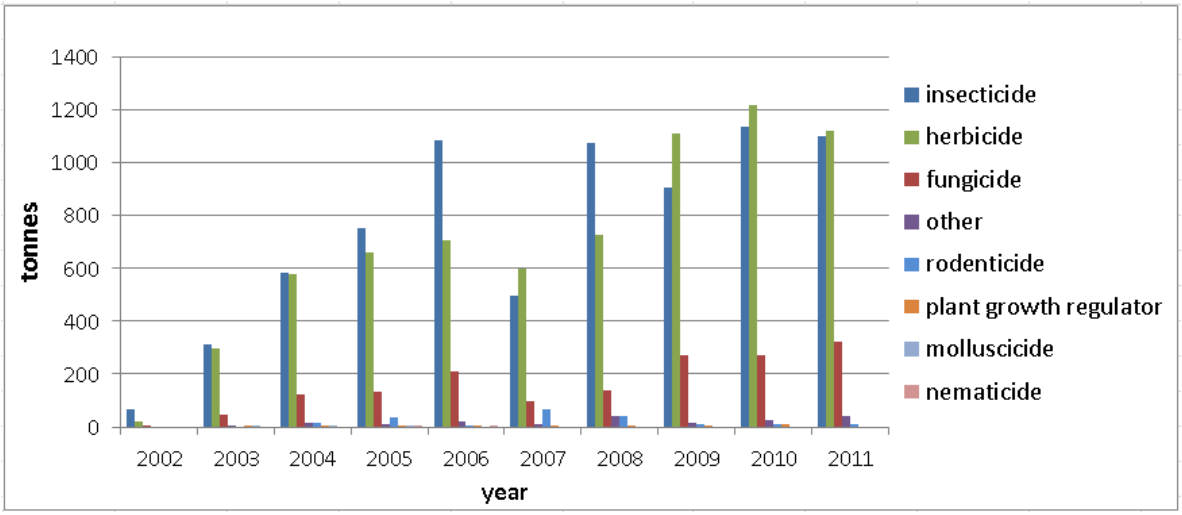

Figure 11: The annual volume per imported product group in the years 2002 – 2011 (tonnes)

The volume of imported pesticides belonging to the eight functional groups corrected for the total agricultural area (Figure 1) is shown in Figure 12. This parameter shows the same pattern as the uncorrected import data in Figure 11.

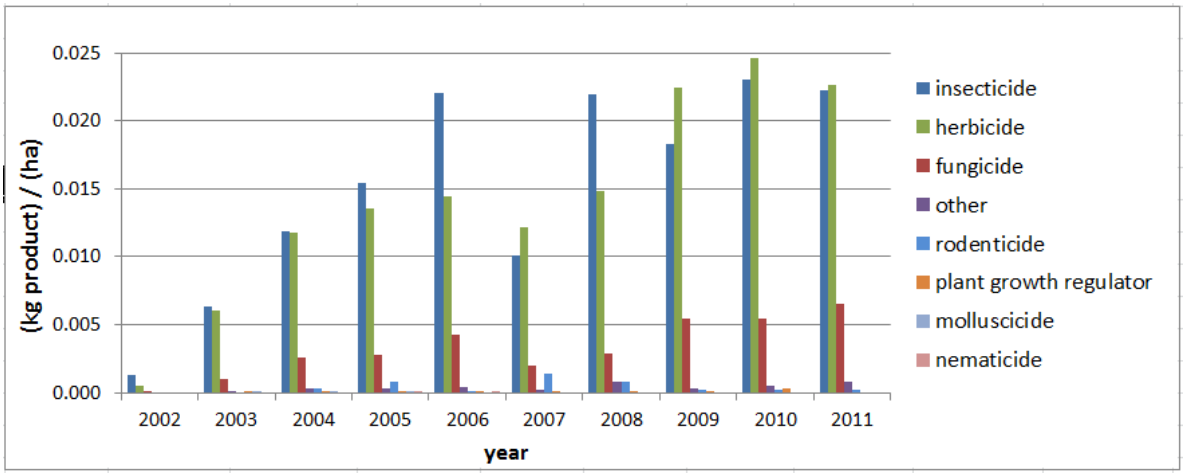

Figure 12: The annual volume per imported product group corrected for the total agricultural area in the years 2002 – 2011 (kg product/ ha)

The volume of imported pesticides corrected for the total agricultural production (Figure 2) is shown in Figure 13. The imports corrected for production still show the same pattern. A slight difference is that insecticide imports peak in 2008 instead of 2010.

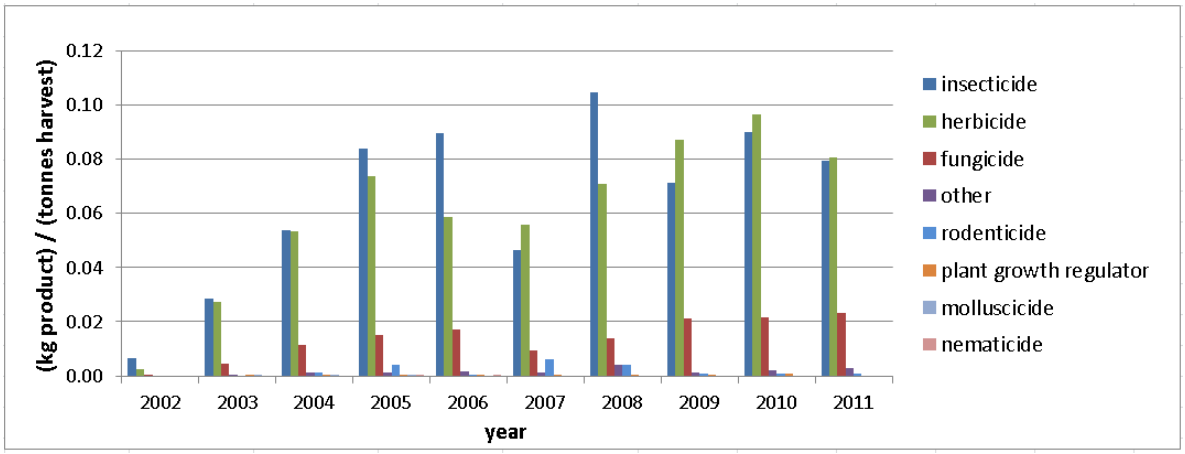

Figure 13: The annual volume per imported product group corrected for the total agricultural production in the years 2002 – 2011 (kg product / tonnes harvest)

Active ingredients

The annual volume of active ingredients per chemical class are shown in Figure 14. These are the major chemical classes based on the total volumes of products imported in the entire period 2002-2011. The volume of active ingredients in the chemical class of organochlorine compounds almost entirely consists of DDT (89% in the year 2005, 97% in 2006, and 100% in 2008). According to the Import data, DDT was only imported in these three years. There are conspicuous peaks in its import in 2006 and 2008, i.e., more DDT was imported that any other class of active ingredients. Endosulfan is the only other active organochlorine ingredient imported in the 10-year period. Another group of active ingredients that are reportedly imported in relative large quantities are the arsenates. Imports of these compounds keep on increasing from 2002 to 2011.

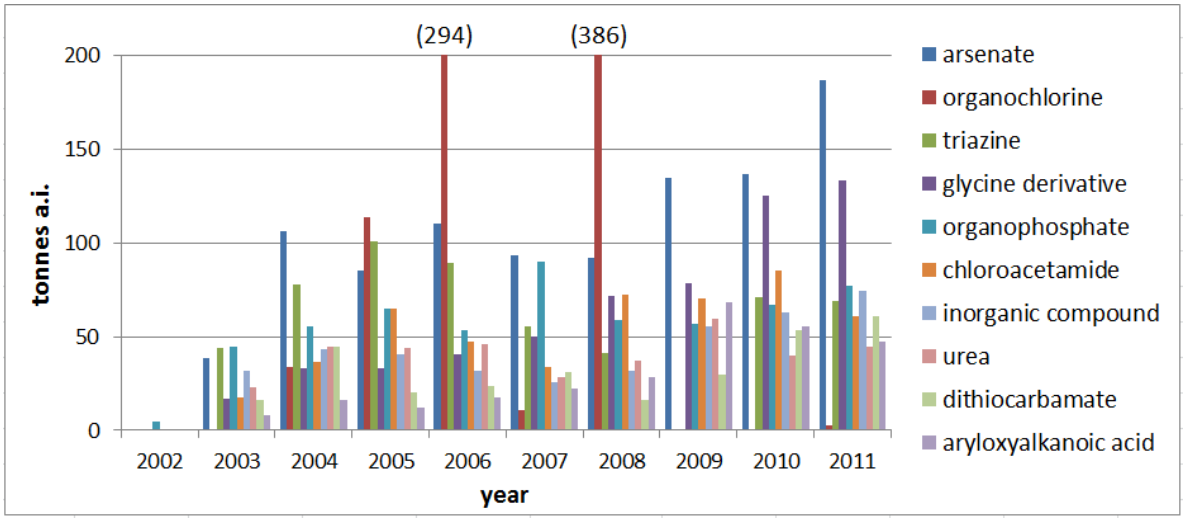

Figure 14: The annual volume per chemical class of active ingredients imported in the years 2002 – 2011 (in tonnes a.i.)

Importers

The five major importers in terms of their contribution to the total volume of imported products in the period 2002-2011 are shown in Figure 15. Agrifocus Lda is the major importer with almost 70% of the total volume of imported products in the entire period 2002-2011. The contributions of importers Agrifocus Lda and Sogrep Lda cover the entire period, whereas Abba Representações covers the years 2003-2011, Agroquímicos Lda covers the years 2002-2010, and Medimoc SA covers the years 2002-

2009. Contrary to these major importers, the majority of the other importers only contribute to the imported volume in one or two years over the 10-year period.

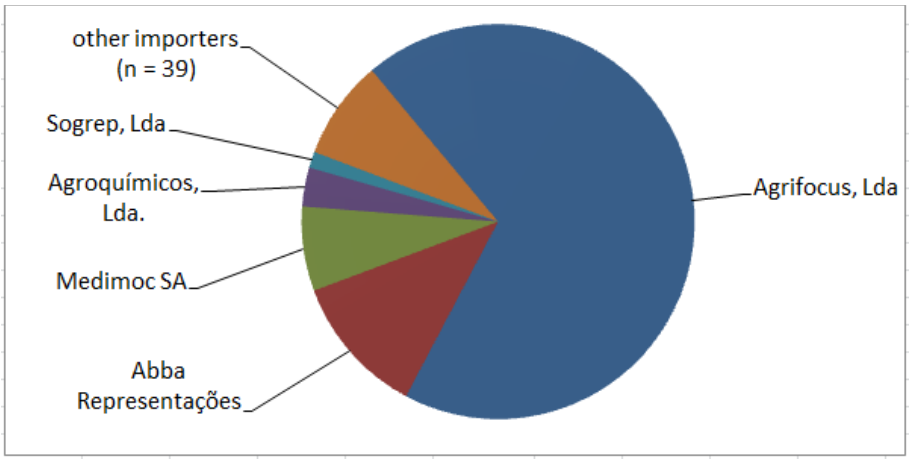

Figure 15: The five major pesticide importers according to the total volume of imported products in the period 2002-2011.

3.2.3 Monetary value

The monetary value of the imported quantity in the Import data is expressed in Metical or New Metical. In order to prepare the graphs and figures in this section, the monetary values in Metical (the years 2002 – 2005 and part of 2006) were converted into New Metical (1 Metical = 0.001 New Metical). The number of import events, the average price per L (or per kg) and the total monetary value of the imported product are shown in Table 5.

Table 5: The annual number of import events with the average price (in New Metical per L or per kg imported product)

Year	Number of import events	Average price per L or per kg in New Metical	Day rate US Dollar	Average price per L or per kg in US dollars	Total value of imports in New Metical (million)	Total value of imports in US dollar
2002	41	22	24.19	0.91	6.3	0.26
2003	263	100	24.02	4.17	115.2	4.80
2004	430	104	21.67	4.80	208.9	9.64
2005	493	112	26.68	4.20	309.5	11.60
2006	494	81	25.23	3.21	289.2	11.47
2007	431	123	25.79	4.77	202.7	7.30
2008	487	108	24.54	4.40	304.0	12.39
2009	563	191	27.40	6.96	459.6	16.78
2010	578	152	34.52	4.41	601.3	17.42
2011	590*	159	27.19	5.85	422.6	15.55

*For this year some import events were merged. Calculations were based on 461 import records.

Products

The annual monetary value of imported pesticides is shown in Figure 16 (in millions New Metical). The value of the imported pesticide products increases over the years with a dip in 2007 and a maximum in 2010. The annual value of imported pesticides corrected for the total agricultural area (Figure 1) is shown in Figure 17 (expressed in New Metical per hectare agricultural land) and the annual value of

imported pesticides corrected for the total agricultural production (Figure 2) is shown in Figure 18. The patterns for these corrected import data are comparable to the uncorrected imports.

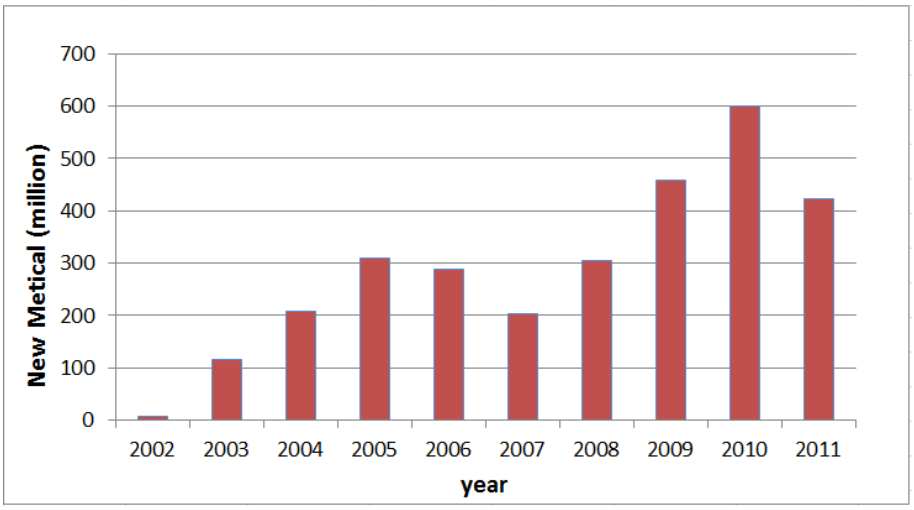

Figure 16: The annual value of imported products in the years 2002 – 2011 (million New Metical)

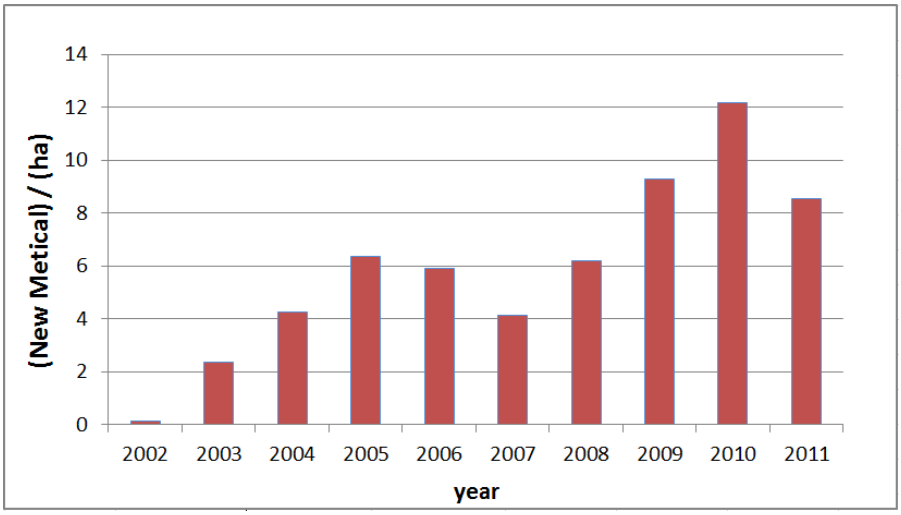

Figure 17: The annual value of imported products corrected for the total agricultural area in the years 2002 – 2011 (New Metical/ha)

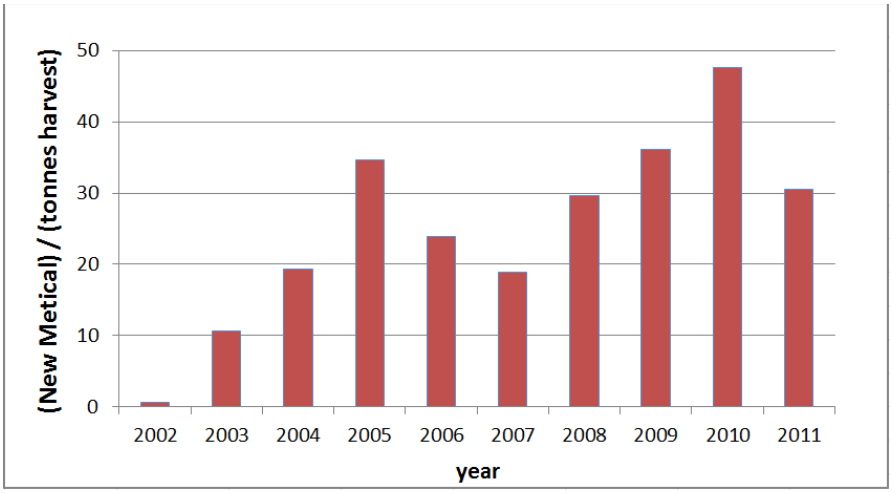

Figure 18: The annual value of imported products corrected for the total agricultural production in the years 2002 – 2011 (New Metical per ton harvested products)

Product groups

The annual value of imported products belonging to the major functional groups is shown in Figure 19. Imported insecticide products represent the highest imported value, followed by herbicides and fungicides. Since the imported volumes of insecticides and herbicides are comparable, imported insecticides must be more expensive than herbicides on average.

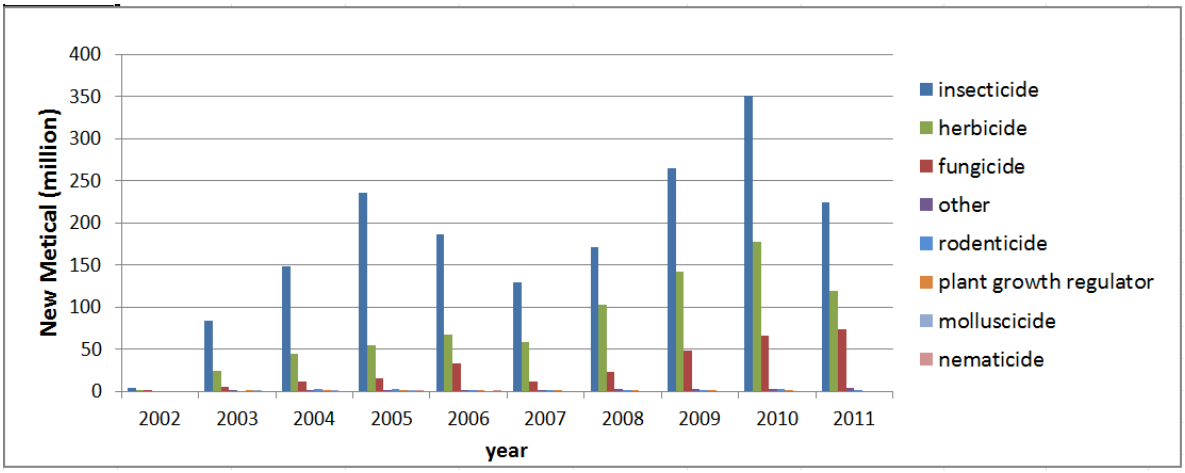

Figure 19: The annual monetary value per imported product group in the years 2002 – 2011 (million New Metical)

Importers

The five major importers according to the contribution to the total value of imported products in the period 2002-2011 are shown in Figure 20. These are also the importers with the major contribution in terms of volume (Figure 15).

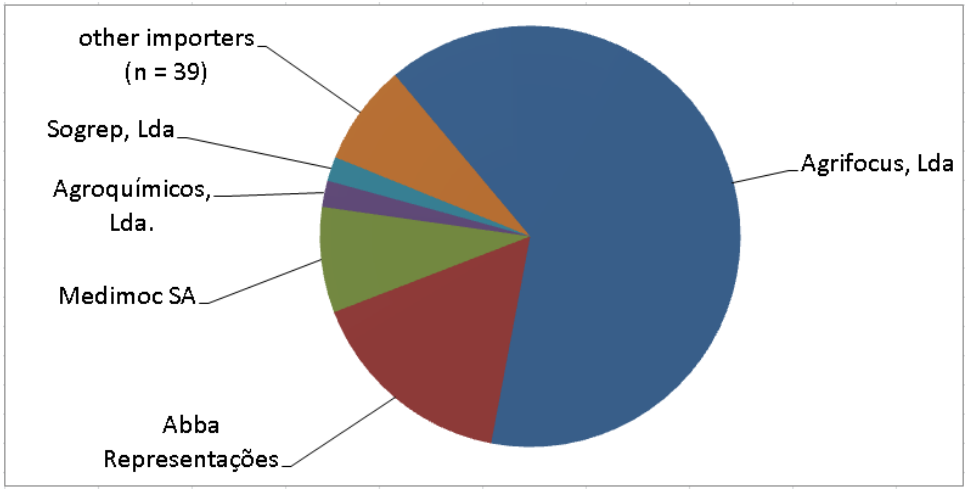

Figure 20: The five major pesticide importers according to the total value of imported products in the period 2002-2011 (in New Metical).

3.3 Acute hazard to human health

The classification of acute hazard to human health is made on a product basis according to Equations 1, 2 and the class boundaries shown in Table 1. The annual number of pesticide products per WHO

Class of acute hazard to human health is shown in Figure 21. Over the study period no products of the highest hazard class were imported (Ia, Extremely hazardous). The number of imported Highly hazardous pesticide products remains constant over the years at approximately 10 pesticides per year. The number and fraction of imported pesticide products unlikely to represent an acute hazard steadily increases over the ten years.

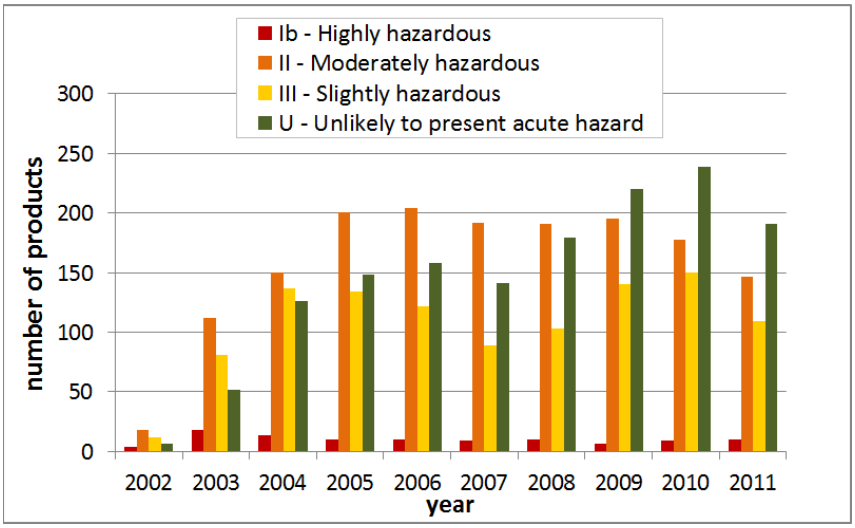

Figure 21: The annual imported number of pesticide products per WHO Class of acute hazard to human health in the period 2002-2011.

The annual volume of pesticide products per WHO Class of acute hazard to human health is shown in Figure 22. This graphs more clearly shows that fraction of imported volumes of moderately hazardous pesticides (Class II) of the total imported volume decreases whereas the fraction unlikely to present a hazard increases.

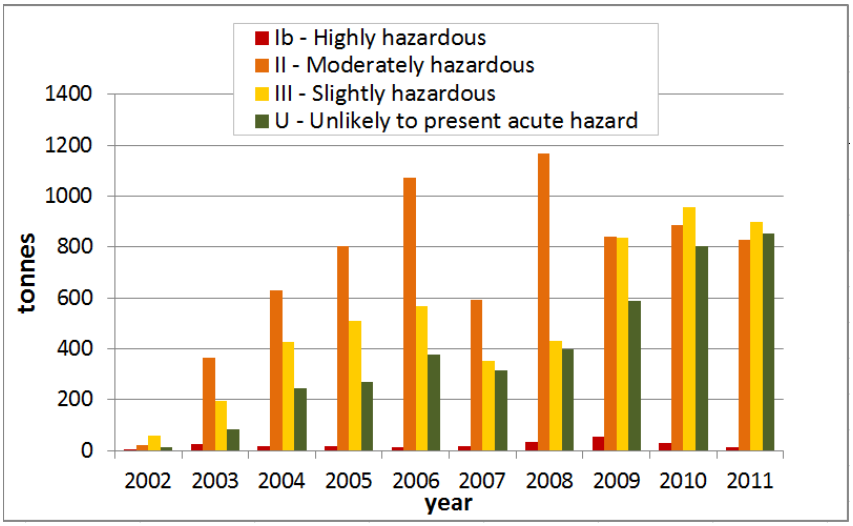

Figure 22: The annual volume of imported products per WHO Class of acute hazard to human health in the period 2002-2011 (tonnes).

In Table 2.1 in Annex 2 the imported pesticide products in WHO class Ib and II for each year are provided. The imported products in these classes change from year to year, but it can be seen that many of the Class Ib products contain only a few active ingredients under varying product names (also see Annex 5): abamectin (trade names: Agrometic, Moz Abamec Plus, Volcano), aldicarb (Temik, Volcano), aluminium phosphide (Moz Aluminium phoshide, Phosgard, Fumaphos, Falfume, Quickphos,

Volcano), fenamiphos (Nemacur, Volamiphos), Methomyl (Kuik), mevinphos (Universal), monocrotophos (Universal, Phoskill), oxamyl (Villa Platoon, Vydate) and terbufos (Rotam, Bongo). These pesticides of primary concern do only represent a small percentage of the yearly imports in Mozambique (<2% per product per year). Furthermore, the Class II products (moderately hazardous) representing >5% of total annual imports in two years or more (secondary concern) contained ametryn, DDT and lambda-cyhalothrin.

3.4 Chronic hazard to human health

The annual numbers and the volumes of imported pesticide per class of chronic hazard to human health are presented on active ingredient basis. The classification of chronic hazard to human health is taken from the Registered pesticide data (Section 2.3.2).

3.4.1 Carcinogenicity

The annual number of active ingredients per class of carcinogenicity is shown in Figure 23. The number of active ingredients in GHS Category 1A or 1B is less than ten per year and the majority of imported active ingredients are non-carcinogenic.

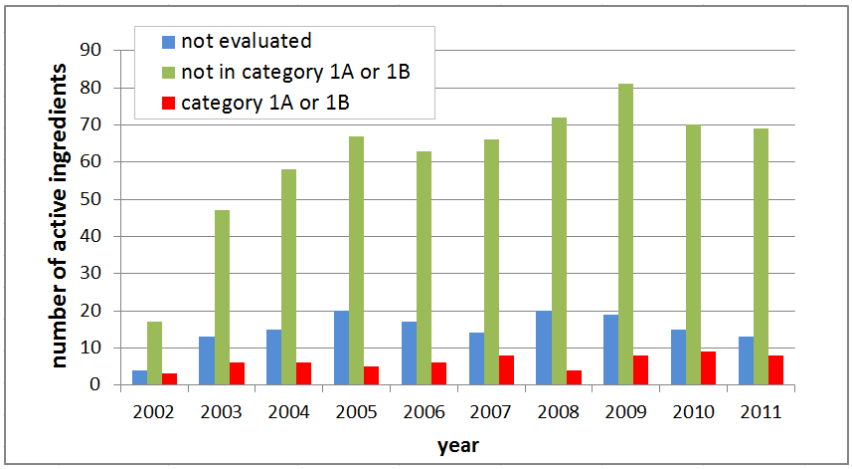

Figure 23: The annual number of imported active ingredients per class of carcinogenic hazard in the period 2002-2011.

The annual volume of active ingredients per class of carcinogenic hazard is shown in Figure 24. This graphs presents a slightly different picture than Figure 23. A relatively large volume of imported active ingredients is not evaluated in terms of carcinogenicity, especially those imported in 2006 and 2008. The imported amount of a.i. in GHS Category 1A or 1B is around 100 tonnes a year.

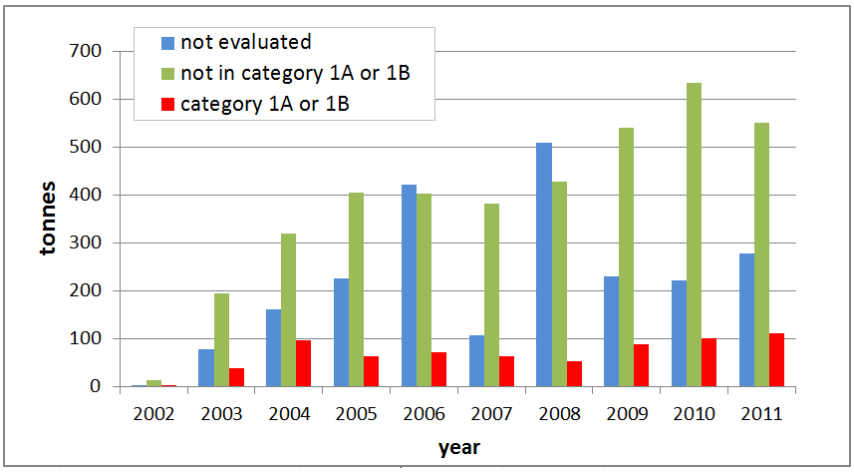

Figure 24: The annual volume of imported active ingredients per class of carcinogenic hazard in the period 2002-2011 (tonnes).

In Table 2.2 in Annex 2 the carcinogenic active ingredients that were imported in Mozambique are summarised. Carcinogenic active ingredients of primary concern (>5% in two years or more) are diuron (trade names: Diuron, Acticide, Rocima, Volcano) and mancozeb (>10 formulated products and trade names, see Annex 5 for the complete list). One carcinogenic active ingredient constituted >1% of the imports in one year, dichlorvos. This a.i. is of secondary concern.

3.4.2 Mutagenicity

The annual number of active ingredients per class of mutagenic hazard is shown in Figure 25. Only very few mutagenic active ingredients are imported in Mozambique. The majority of imported a.i. is non-mutagenic and for some substances there is no information.

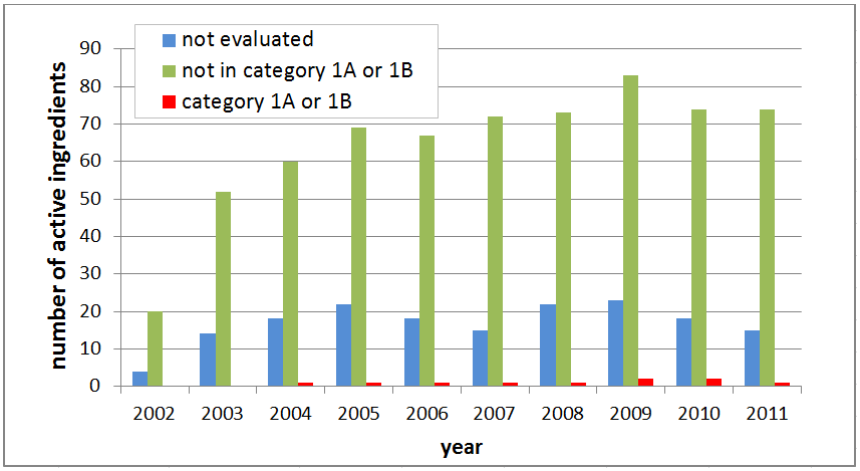

Figure 25: The annual number of imported active ingredients per class of mutagenic hazard in the period 2002-2011.

The annual imported volume of active ingredients per class of mutagenic hazard is shown in Figure 26. In terms of imported quantities, mutagenic active ingredients are almost negligible. As for the carcinogens, in 2006 and 2008 relative large volumes of active ingredients imported for which there is no information on their mutagenicity.

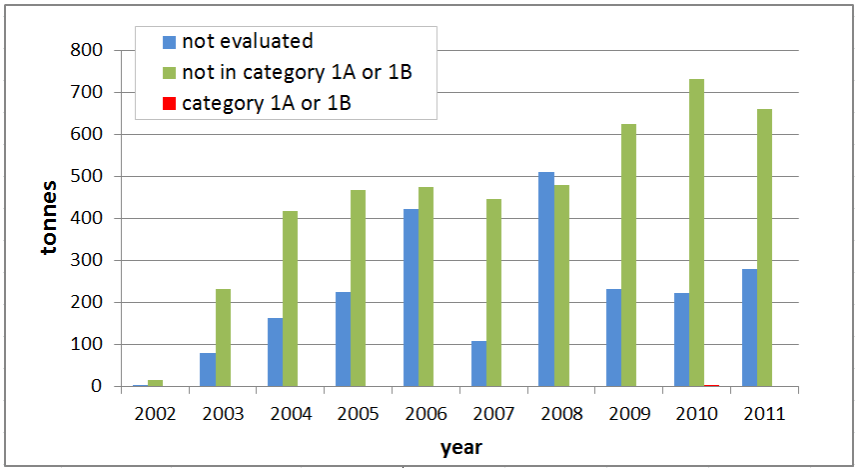

Figure 26: The annual volume of imported active ingredients per class of mutagenic hazard in the period 2002-2011 (tonnes).

In Table 2.3 in Annex 2 the mutagenic active ingredients that were imported in Mozambique are summarised. Only two active ingredients occur in this table, benomyl and carbendazim. They are not imported in Mozambique in large quantities (0.3% of total yearly imported volume or less) and are not compounds of primary or secondary concern according to the criteria used.

3.4.3 Toxicity to reproduction

The annual number of active ingredients per hazard class of reproductive toxicity is shown in Figure 27. Only very few a.i. that are toxic to reproduction are imported.

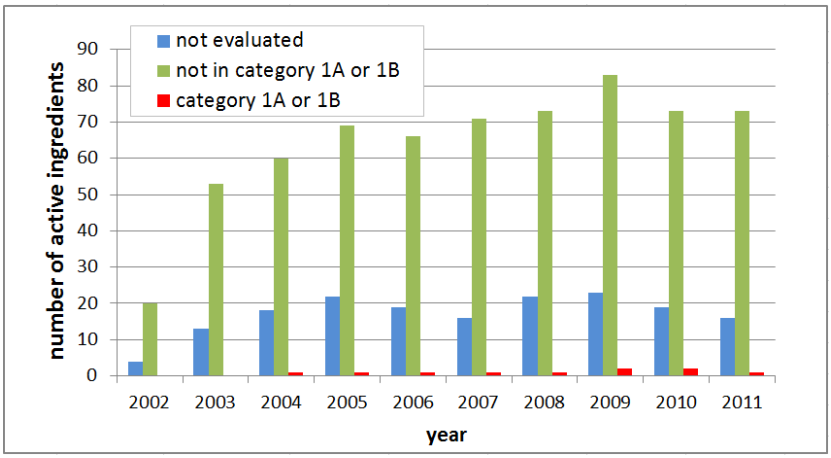

Figure 27: The annual number of imported active ingredients per hazard class of reproductive toxicity in the period 2002-2011.

The annual volume of active ingredients per hazard class of reproductive toxicity is shown in Figure 28. Again, almost no reproductively toxic a.i. are imported in Mozambique, but in 2006 and 2008 relative large volumes of active ingredients imported for which there is no information on reproductive toxicity.

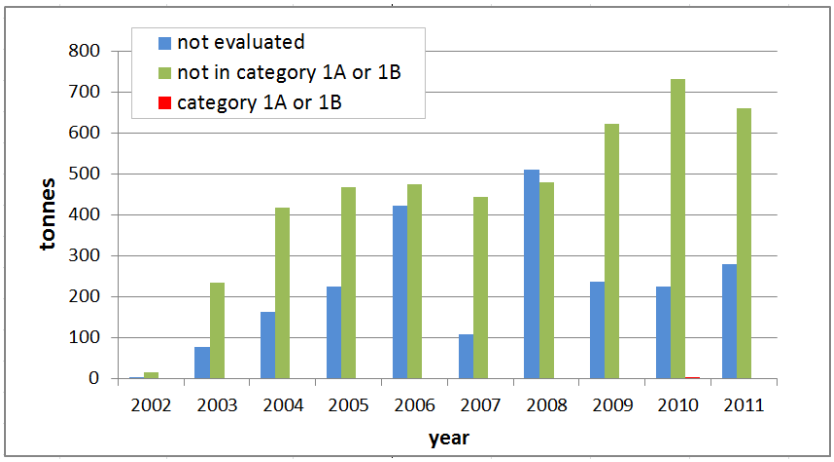

Figure 28: The annual volume of imported active ingredients per hazard class of reproductive toxicity in the period 2002-2011 (tonnes).

Table 2.4 in Annex 2 summarises the active ingredients that were imported in Mozambique and that are toxic to reproduction. The compounds in this table are the same as the mutagenic compounds (Table 2.3 in Annex 2): benomyl and carbendazim. These are not of primary or secondary concern (see §3.4.2).

3.5 Acute environmental hazard

The numbers and volumes per environmental hazard class are presented on active ingredient basis.

3.5.1 Fish

The annual number of imported active ingredients per fish toxicity class is shown in Figure 29. The graph shows that the active ingredients imported in Mozambique are relatively toxic to fish. More than half of the a.i. is moderately to highly toxic to fish and the relative numbers change little from 2002 to 2011.

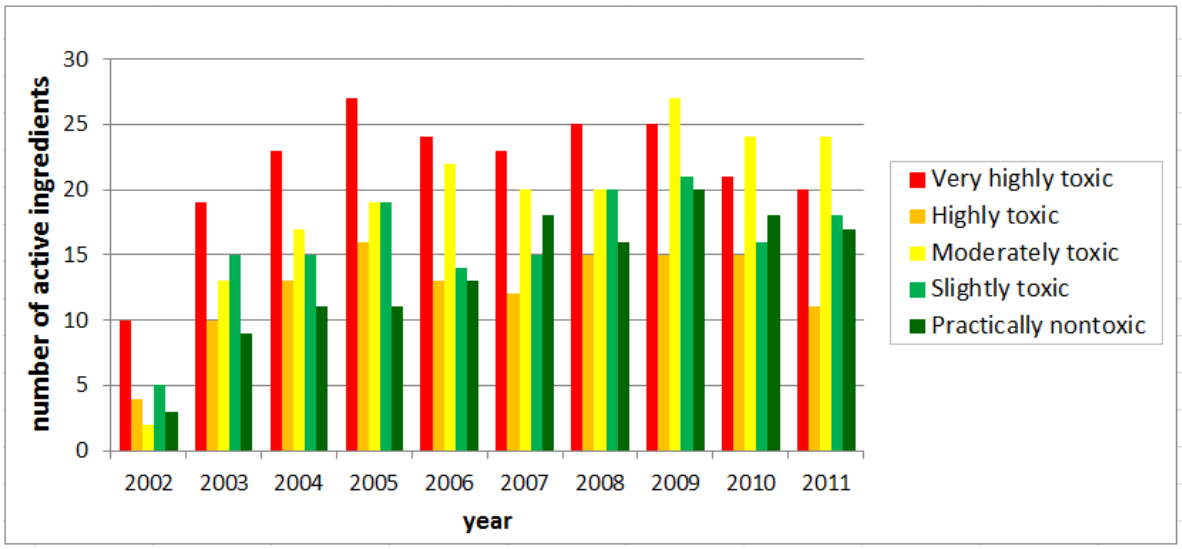

Figure 29: The annual number of imported active ingredients per fish toxicity class in the period 2002-2011.

The annual volume of active ingredients per fish toxicity class is shown in Figure 30. This image is different from Figure 29. Here, it can clearly be seen that imported volume of active ingredients that is only slightly or practically non-toxic to fish increases over the years. In 2011 more than half of the imported volume of a.i. belongs to these two classes. In 2005, 2006 and 2008 peaks can be observed for the imported volumes of a.i. that are moderately toxic to fish. These are caused by the relatively high amounts of DDT imported in Mozambique in those years.

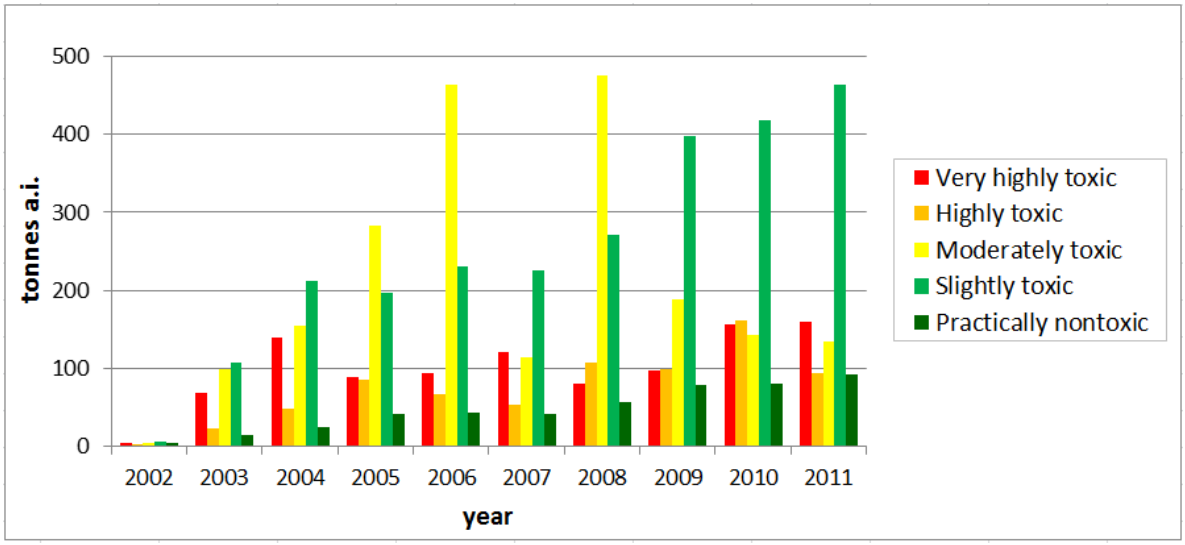

Figure 30: The annual volume of imported active ingredients per fish toxicity class in the period 2002-2011 (tonnes).

3.5.2 Aquatic invertebrates

The annual number of active ingredients per *Daphnia* toxicity class is shown in Figure 31. Many imported active ingredients are toxic to *Daphnia* and thus to aquatic invertebrates. The relative numbers of imported that are toxic change little over time.

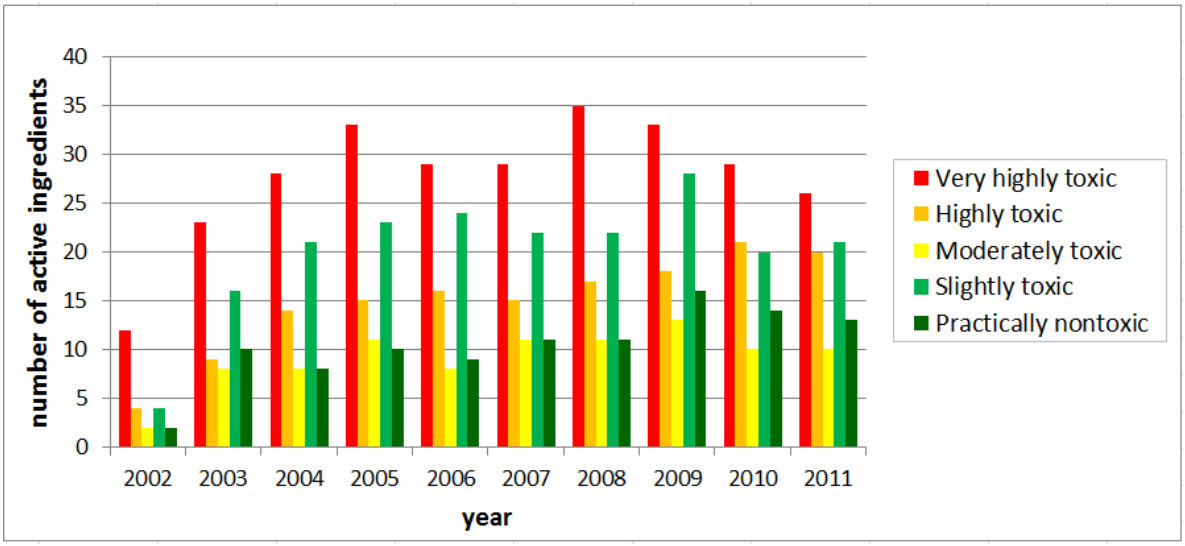

Figure 31: The annual number of imported active ingredients per *Daphnia* toxicity class in the period 2002-2011.

The annual volume of active ingredients per *Daphnia* toxicity class is shown in Figure 32. Expressed as imported volumes of a.i., the fractions highly and very highly toxic a.i. are lower, with the exception of the two familiar peaks in 2005, 2006 and 2008 (DDT). Over the years the relative imported volume of compounds that are slightly or practically non-toxic increases.

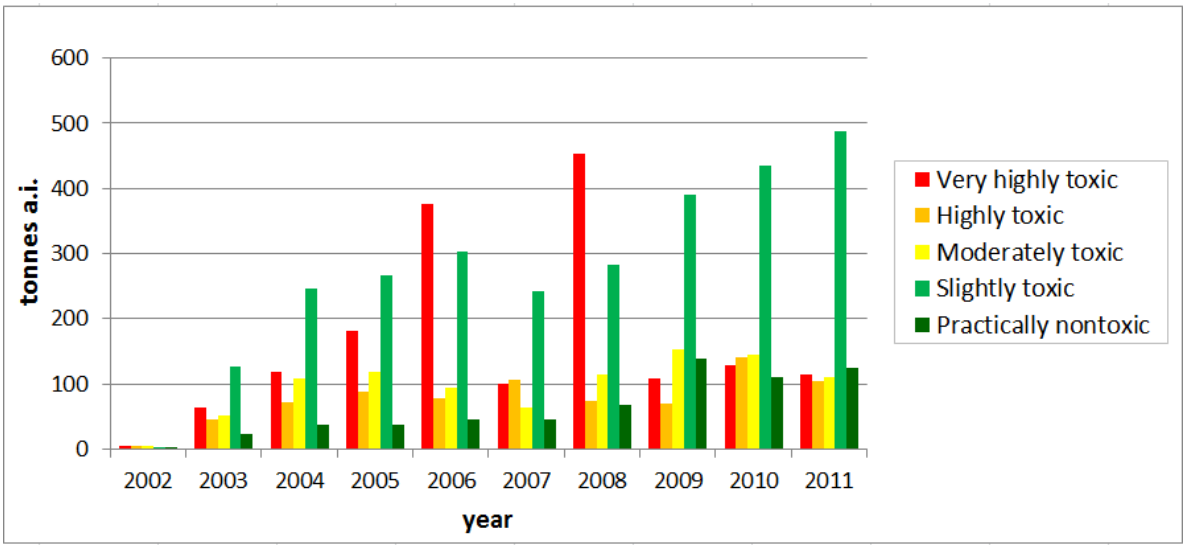

Figure 32: The annual volume of imported active ingredients per *Daphnia* toxicity class in the period 2002-2011 (tonnes).

3.5.3 Algae

The annual imported number of active ingredients per algae toxicity class is shown in Figure 33. More than half of the active ingredients imported in Mozambique are moderately, highly or very highly toxic to algae and relative numbers change little over time.

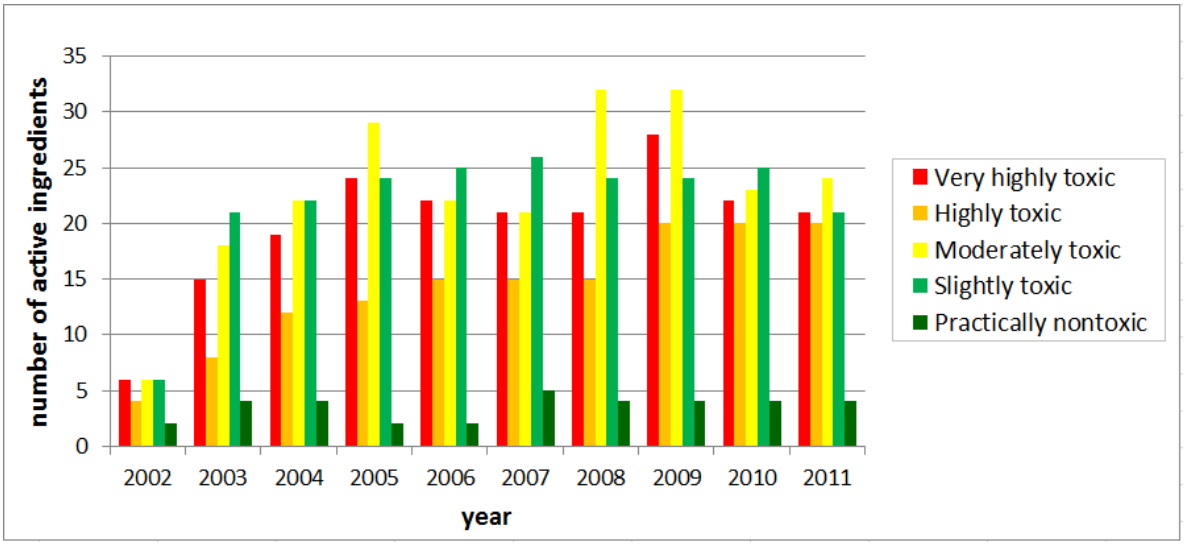

Figure 33: The annual number of imported active ingredients per algae toxicity class in the period 2002-2011.

The annual volume of active ingredients per algae toxicity class is shown in Figure 34. From 2004 to 2011 the imported volumes a.i. per class change little. The exceptions are the peaks for slightly toxic a.i. in 2005, 2008 and 2009, caused by the relatively high imports of DDT.

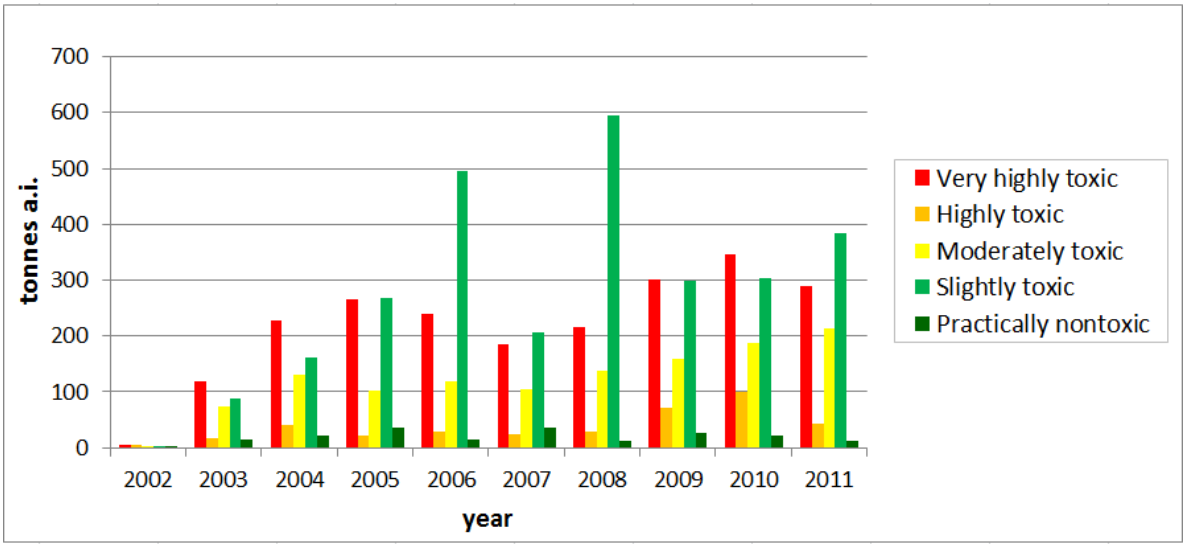

Figure 34: The annual volume of imported active ingredients per algae toxicity class in the period 2002-2011 (tonnes).

3.5.4 Bees

The annual number of active ingredients per bee toxicity class is shown in Figure 35. The relative imported numbers of a.i. that are slightly or very slightly toxic to bees is higher than for the aquatic organisms in the previous paragraphs, i.e., these two classes represent more than half of the imported a.i.

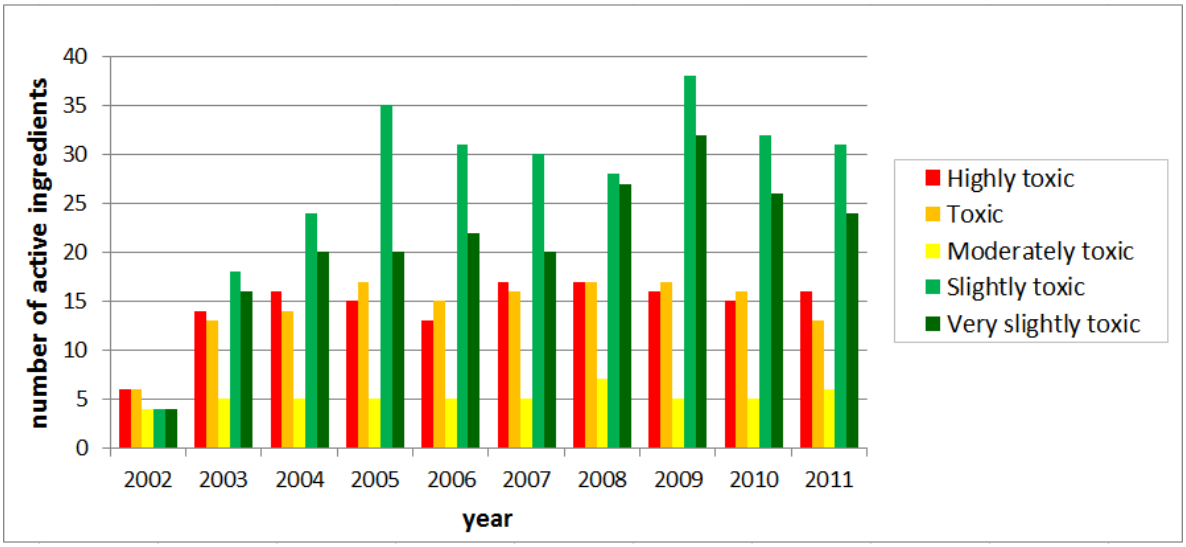

Figure 35: The annual number of imported active ingredients per bee toxicity class in the period 2002-2011.

The annual volume of active ingredients per bee toxicity class is shown in Figure 36. In terms of imported volume the a.i. that are slightly to very slightly toxic are even more represented, more than 75% in most years and increasing.

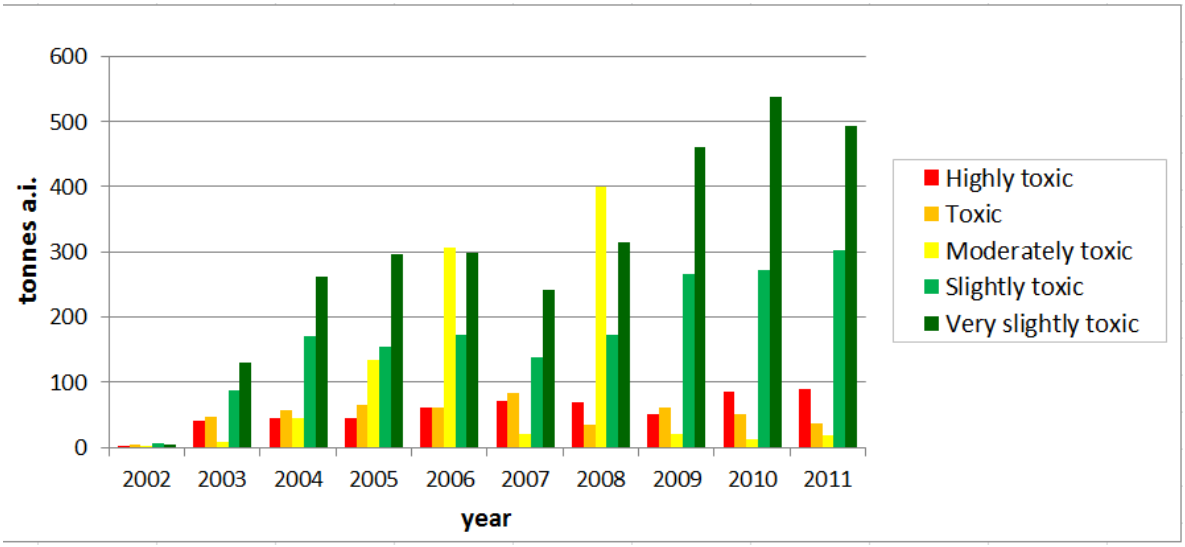

Figure 36: The annual volume of imported active ingredients per bee toxicity class in the period 2002-2011 (tonnes).

3.6 Environmental Toxic Load

The Environmental Toxic Load (ETL) indicators are calculated according to Equation 3 and presented in figures as the annual sum of all active ingredients imported. Compounds with the major contribution to the ETL are mentioned in the text. Annex 3 contains tables with the relative contributions of the 175 active ingredients to the total indicator values.

3.6.1 Fish

The annual Environmental Toxic Load for fish is shown in Figure 37. This indicator shows more changes over time than can be seen in the classification of imported numbers (Figure 29) and volumes (Figure 30) of active ingredients. The ETL for fish increases from 2002 to 2004 and peaks in 2010. In 2011 the ETL value is more than halved compared to 2010.

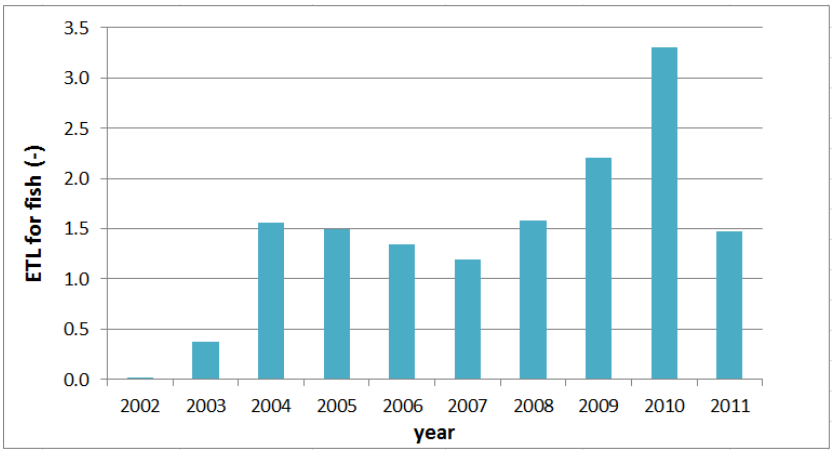

Figure 37: The annual Environmental Toxic Load for fish of active ingredients imported in Mozambique in the period 2002-2011.

Over the years one compound explains 50% or more of the total ETL for fish in more than two years (Table 3.1, Annex 3), lambda-cyhalothrin (trade names: Cyclon, Demand, Duduthrin Fortis, Icon, Iconet, Karate, Moz Lambda-cyhalothrin, Revival, Zakaka, Zakanaka, see Annex 5). It is therefore of primary concern. From 2005 to 2011 lambda-cyhalothrin was solely responsible for more than 80% of the ETL value (with the exception of 2007: 67%). The ETL peak value in 2010 is also explained by lambda-cyhalothrin. Active ingredients of secondary concern for fish are aluminium phosphide, chlorpyrifos, cyfluthrin, cypermethrin and endosulfan.

3.6.2 Aquatic invertebrates

The annual Environmental Toxic Load for the water flea *Daphnia* is shown in Figure 38. The ETL for *Daphnia* also increases initially, but from 2004 to 2011 it fluctuates between 3.0 and 7.0. It is considerably reduced in 2011 compared to 2010.

Over the years ETL values are determined by a limited number of active ingredients (Table 3.2 in Annex 3). They are mainly organophosphate compounds and synthetic pyrethroids: chlorpyrifos, cypermethrin, DDT (DDT, again, only in 2005, 2006 and 2008), dichlorvos, ethion, fenvalerate, lambda-cyhalothrin and pirimiphos-methyl. These active ingredients did not explain more than 50% of the ETL value in 2 years or more, but only >10% in one year or more. They are therefore categorised as of secondary concern for aquatic invertebrates according to the criteria set out in §2.4.

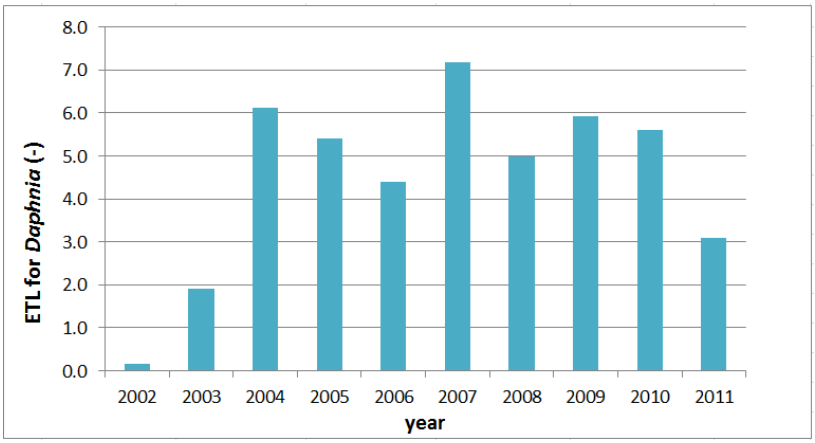

Figure 38: The annual Environmental Toxic Load for *Daphnia* of active ingredients imported in Mozambique in the period 2002-2011.

3.6.3 Algae

The annual Environmental Toxic Load for algae is shown in Figure 39. The toxic load of the imported active ingredients to algae increases from 2002 to 2005, decreases in 2006 and 2007 and increases again the following years. The pattern closely resembles the pattern observed for the total volume of pesticide products imported in Mozambique over the same period (Figure 7).

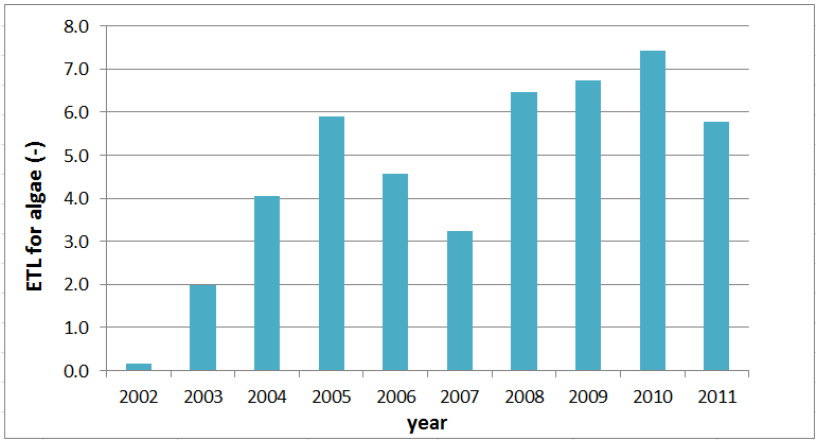

Figure 39: The annual Environmental Toxic Load for algae of active ingredients imported in Mozambique `in the period 2002-2011.

In all years, except 2002, 69% to 85% of the ETL value for algae is caused by the import of the a.i. acetochlor (Table 3.3, Annex 3). This is the only active ingredient of primary concern to algae. Trade names are Acetochlor, Bullet, Villa and Volcano (Annex 5). Paraquat contributes 5%-21% from 2003 to 2011 and 99% in 2002. The third a.i. that causes a potential hazard for algae is ametryn, which explains 4%-12% of the ETL yearly from 2003 to 2011. Both compounds represent > 10% of the ETL in more than one year and are therefore classified as of secondary concern.

3.6.4 Bees

The annual Environmental Toxic Load for bee is shown in Figure 40. The ETL increases considerably from 2002 to 2008 and then drops again. From 2009 to 2011 it remains at almost the same level of 0.07-0.08.

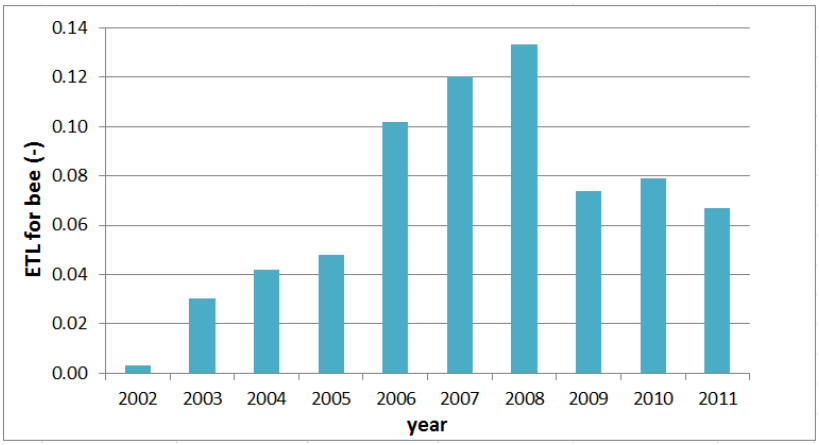

Figure 40: The annual Environmental Toxic Load for bees of active ingredients imported in Mozambique in the period 2002-2011.

The active ingredients that together determine most of the ETL values for bees vary considerably from year to year without any consistent trends in time (Table 3.4, Annex 3). One active ingredient constitutes >50% of the ETL value in more than 2 years and is of primary concern for bees, imidacloprid (trade names: Bandit, Condifor, Courag, Gaucho, Imidabiogel, Imidacel, Imidagold, Maxforce Quantum, Midaclordan, Monceren, Moz Imidacloprid, Premise, Protect, Quick Bait Spray Fly Bait, Seed Plus and Thunder, see Annex). The a.i. that are of secondary concern are bendiocarb, chlorpyrifos, cyfluthrin, cypermethrin, deltamethrin, lambda-cyhalothrin, profenofos and thiamethoxam.

3.7 Groundwater leaching potential

The calculated GUS indicator and the groundwater leaching potential class of the active ingredients in the imported products is listed Table 4.1 in Annex 4. The annual number of active ingredients per groundwater leaching potential class is shown in Figure 41. Over the whole period most imported a.i. have a low to very low leaching potential. Relative numbers in the different classes change little over time.

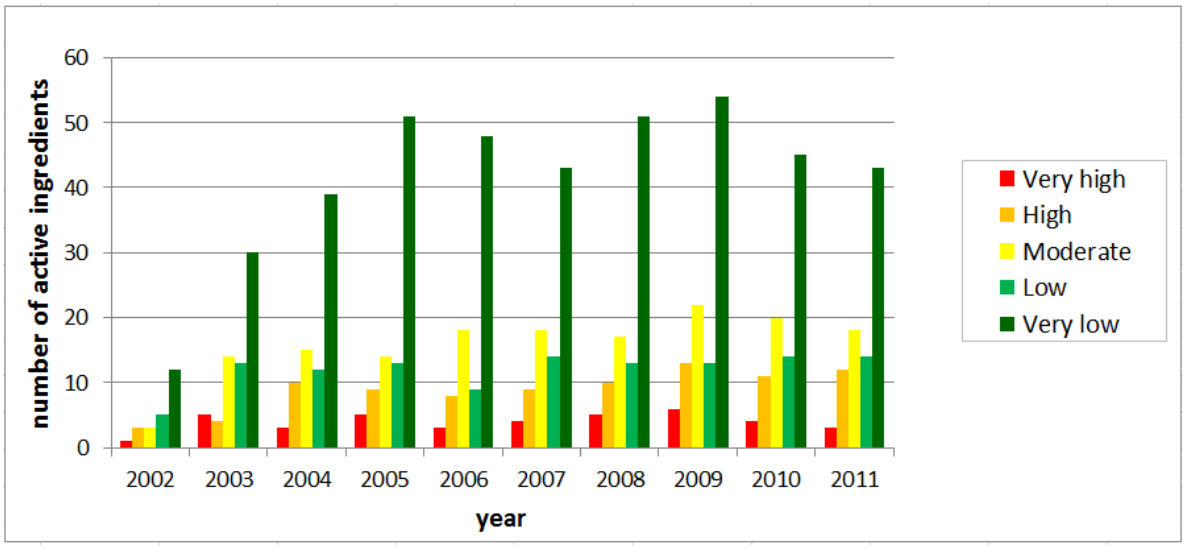

Figure 41: The annual number of imported active ingredients per groundwater leaching potential class in the period 2002-2011.

The annual volume of active ingredients per groundwater leaching potential class is shown in Figure 42. In terms of imported volume the a.i. with a moderate leaching potential are more important than in terms of imported numbers of a.i. (Figure 41), but the volumes of a.i. with a high or very high leaching potential are small. The two peaks of imported pesticides with a very low leaching potential in 2006 and 2008 are caused by DDT that strongly absorbs to particles and organic matter (GUS: -4.5).

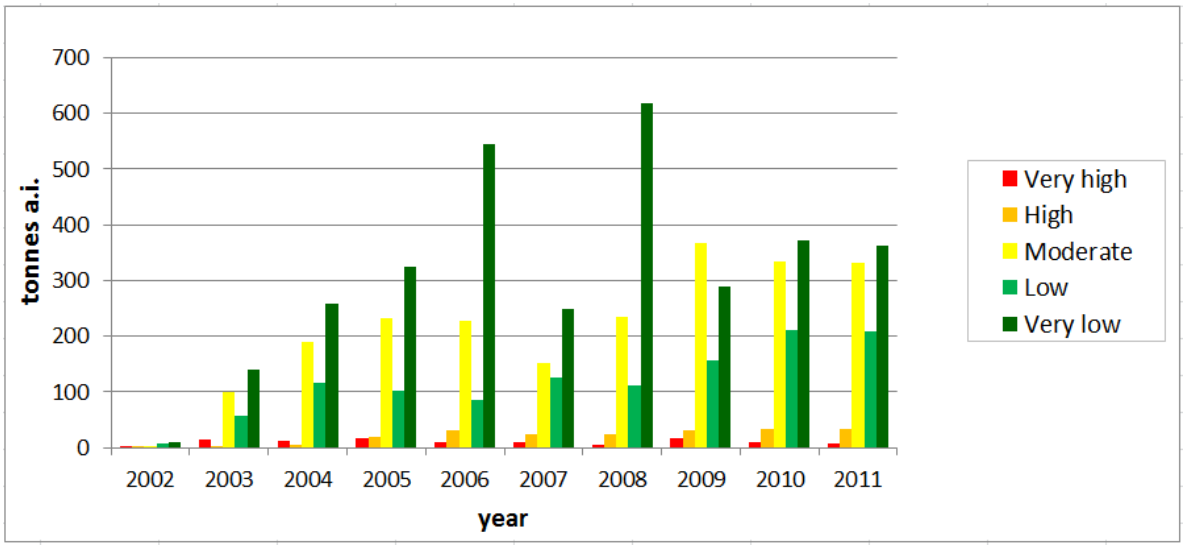

Figure 42: The annual volume of imported active ingredients per groundwater leaching potential class in the period 2002-2011 (tonnes).

The percentage of the total yearly imported volumes of active ingredients with a very high (Class 5) or high (Class 4) potential to leach to the groundwater are listed in Table 4.2 in Annex 4. Compounds of primary concern, i.e., Class 5 a.i. that constitute more than 1% of the total imported volume in two years or more, are methyl bromide (trade name: Volcano) and tebuthiuron (Volcano, Volcano Bundu). Of secondary concern are Atrazine (Class 4), Clomazone (Class 4), Hexazione (Class 5), Imidacloprid (Class 4) and Propoxur (Class 4).

4 Discussion

This chapter summarizes and discusses the main findings of the study. First the limitations of the methods are discussed. Secondly the trends in time of pesticide use, hazards and the Environmental Toxic Loads (ETLs) are analysed.[2]

4.1 Limitations and advantages of the methods

4.1.1 Use of import data

The analyses, trends and calculated indicators reported in this report are entirely based on import data. It is implicitly assumed that import data can be used as a surrogate for actual usage data when the potential hazards of formulated products and active ingredients are assessed. The assumption in that case would be that imported compounds are applied in the field in the same year that they are imported. It must be well understood that this is not the case in reality. Imported pesticide products may not be sold immediately, and if they are sold they may not be applied instantly. The actual hazards and risks of the use of the imported pesticides may well occur later and will depend on the actual use pattern, i.e., all applied within a short period or applied in portions over larger periods. We do, however, know that all imported pesticides are actually used in Mozambique and are not further exported.

There was no background information available to interpret several conspicuous observations such as the limited number of import events in the years 2002 and 2003, and for particular products, the large fluctuations of the volumes imported in subsequent years. An example is the imported volume of products based on DDT which alternately showed high import peaks in some years and absence of imported volumes in others.

Because import data were used in this report as a proxy for data on actual national use, care must be taken when interpreting and communicating the findings of the study.

4.1.2 Hazard assessments

The hazard assessments for aquatic organisms, groundwater and bees that were done during this study rank pesticides relative to each other from high to low hazard. The hazard assessments do not provide information on the actual risks in the field posed by these pesticides. Real risks to aquatic organisms, bees and groundwater depend on both the toxicity of the pesticide and the actual exposure of organisms to the pesticide. Exposure is, among other things, determined by pesticide formulation, soil properties, climate, application regimes, conditions during application, persistence of pesticides in the ecosystem, the presence and distance to surface water bodies, presence of fish and bees, buffer strips and other mitigation techniques employed, etc. These factors were not taken into account. Hazard assessments such as these, however, can be used to decide whether follow-up risk assessments are required.

The risk of judging pesticides on the basis of hazard assessment only is that farmers may be encouraged to base their choice of pesticide on only one parameter — low toxicity — without due consideration being taken into account of the overall risk, which requires the total exposure to also be considered. While, for pesticides with a low toxicity, repeated use may lead to increased exposure and therefore pose a higher risk than pesticides with a high toxicity but low rates of exposure. Therefore

[2] Parts of this discussion, especially about the methods, is the same as for the exercise that was done for pesticides used in cotton (De Blécourt et al., 2010). In these cases we have copied parts of this report and only slightly modified them (§4.1.2, §4.1.3).

drawing conclusions on hazard indicators only is not advised and it is recommended to use a simplified risk assessment method, for example PRIMET (Peeters et al., 2008).

The hazard assessments for aquatic organisms do not take into account the persistence of the compound. Highly toxic pesticides with a low persistence in the ecosystem can pose a lower risk to aquatic organisms than persistent compounds with lower toxicity. The approach could in the future be improved by including persistence and use patterns in the equation.

The hazard assessments for groundwater take into account mobility and degradation in soil, but not toxicity of the pesticides. Whether the use of a specific compound is a risk to groundwater depends on the toxicity of the compound, the distance to groundwater and the use of the groundwater. The hazard assessment for groundwater can be improved by including toxicity in the indicator.

4.1.3 Environmental Toxic Load

Environmental Toxic Load (ETL) indicators were used to evaluate the consequences of changes in pesticide use on average toxic loads to the environment. The ETL was calculated separately for fish, aquatic invertebrates (*Daphnia*), algae and bees. The ETL gives an indication of the average amount of toxic pressure applied on one (1) hectare of agricultural land in one (1) year. The ETL indicator combines the average amount of pesticides applied in the total agricultural area of the country with the toxicity of the active ingredients used. The actual exposure to the pesticide is not included in the ETL because this would require modelling. The ETL, therefore, is not an indicator of the risk associated with the use of a pesticide, or the actual impact on organisms in the field, but rather the ETL is a composed indicator for the relative hazard based on pesticide imports. For example, the active ingredient of an imported pesticide may be toxic to bees and increase the ETL value. But when it is a granular formulation and the pesticide is non-systemic, bees may never be exposed.

The ETL is used to compare average toxic loads to the environment (1) between pesticides, (2) between years and (3) in the case of the aquatic toxicity also between different groups of aquatic species (fish, water fleas and algae). As the ETL is averaged over the whole agricultural area, the ETL does not account for differences between regions where relatively high or low amounts of toxic substances are used. So even when the ETL is relatively low for a country in a given year, there could still be environmental risks in a particular area where a highly toxic active ingredient is used extensively.

4.1.4 GUS index

The GUS index has limited data needs and should be considered as a simple indicator of the groundwater leaching potential. It takes into account the persistence (degradation half-life) and mobility (sorption coefficient to soil organic carbon) of active ingredients. The leaching potential of metabolites is not considered, although some of these compounds pose greater hazards than their precursor. In addition, pH dependent sorption is not considered in the GUS. Using a combined sorption coefficient for calculating the GUS for soils with different pH, would result in a shift to a higher groundwater leaching potential class. For these reasons, the results of the analysis of the groundwater leaching potential of the imported active ingredients should be interpreted with some care.

4.1.5 Advantages of hazard analysis

In the previous paragraphs especially the limitations of the methods and indicators were discussed. However, the hazard-based method and the ETL also have certain advantages over more complex risk-based indicators. The amount of parameters needed for the analyses is limited. This is an advantage in developing countries where adequate data on pesticide use and exposure may often be very difficult to obtain. Furthermore, the methods are very suitable for trend analysis because data are analysed in a uniform way. Finally, these analyses are relatively cheap and fast. When time and budget are limiting factors their use will quickly provide some general insights which allows for a more focussed risk assessment as a follow-up.

4.2 Trends in pesticide imports

In this study trends in pesticide imports and hazards were assessed over a ten year period, from 2002 to 2011. During these years the total agricultural area of Mozambique, as reported by FAOSTAT, only very slightly increased (1.4%). Agricultural production, i.e., harvests that were reported for the various crops grown in the country, increased 40%, from 10 million tonnes in 2002 to 14 million tonnes in 2011. Because the total agricultural area only changed little during the same period, it must be concluded that on the whole agriculture in the country must have intensified.

This assumed intensification is reflected in the trend of the total volume of pesticides imported in the country. Imports were lowest in 2002, but it is not clear if the import data that were compiled for this year are complete. However, from 2003 to 2011 the imported total volume of formulated pesticides also increased considerably, from some 670 tonnes in 2003 to more than 2,500 tonnes in 2010 and 2011 (there was a temporary decrease in 2007). The number of active pesticide importers also increased over the study period, from a mere 5 in 2002 to more than 15 in 2011. The number of active importers temporarily declines around 2007, which could perhaps explain part of the reduced pesticide imports observed around the same time. Over the 10 year period one importer, Agrifocus Lda, is responsible for almost two thirds of the total imported volume of pesticide products.

The type of pesticides imported in Mozambique is very consistent over time. The majority of products consists of insecticides, followed by the herbicides and fungicides. The imported amounts of other type of pesticides such as rodenticides, nematicides, molluscicides and growth regulators is relatively small.

The trends in the imported volumes of active ingredients will be discussed in terms of their potential hazards in the following paragraphs. In general it could be observed that some older and very noxious active ingredients like methyl bromide may have been phased out already because they are not imported in later years. Other compounds keep on being used. The import data for 2005, 2006 and 2008 for example show some conspicuous peaks for DDT (Figure 13) which are repeatedly reflected by some of the human health and environmental indicators.

4.3 Human health hazard

The acute human health hazard of the pesticides imported in Mozambique was evaluated using the WHO classification for formulated pesticide products. Whereas the total volume of imported pesticides increased from 2002 to 2011, the fraction of highly hazardous products of the imported volume decreased and the fraction of products with a (very) low hazard increased. Over the period 9 active ingredients of primary concern (in Class 1b products) were imported, but mostly in rather limited quantities. Pesticide products containing aluminium phosphide were the most consistently imported Class Ib products over the 10-year period. However, some Class II products were imported in larger volumes and therefore of secondary concern. These contained active ingredients of secondary concern such as ametryn, DDT and more recently lambda-cyhalothrin.

Only few pesticide products with a known chronic hazard were imported in the country although imported volumes may still range from several tens to several hundred tonnes of the active ingredients. Compounds of primary concern are mancozeb and diuron (both carcinogenic), dichlorvos (also carcinogenic) is of secondary concern.

4.4 Environmental hazard

A considerable number of the pesticides imported into Mozambique are acutely toxic to fish, aquatic invertebrates, algae and to bees. However, the less hazardous pesticides represent a much higher volume of imports. For all four groups of species, the volume of slightly toxic or very slightly toxic active ingredients is highest. There are no clearly observable trends in time in environmental hazard of the imported products. Numbers and imported volumes for all toxicity classes increase as a

consequence of increasing imports, but there are no clear trends towards the import of more hazardous or less hazardous active ingredients in time.

The picture is somewhat different when the environmental toxic load is evaluated. This indicator corrects for the total agricultural area and cumulates the relative hazards of all imported active ingredients. All calculated ETL values increase during the first three or four years of the 10-yr. period. In other words, because more pesticides are imported per hectare of arable land, the potential environmental hazard increases (assuming that these pesticides are actually used). After this initial period the trends are slightly different.

The ETL for fish fluctuates around 1.5 from 2004 to 2008 and then suddenly increases in 2009 and 2010. In 2011 the ETL is back at c. 1.5 (Figure 37). During the first years many active ingredients that are well known to be very toxic to fish contribute to the ETL value (endosulfan, chlorpyriphos etc.). In the later years the ETL is for a very large part the result of the import of lambda-cyhalothrin (only compound classified as of primary concern). This pesticide is also responsible for the ETL peak values.

The relative hazard for aquatic invertebrates (*Daphnia*) also fluctuates but decreases in 2011 (Figure 38). The ETL usually depends on a combination of several organophosphate and synthetic pyrethroid compounds, but in changing combinations. Over the last four years, chlorpyrifos and lambda-cyhalothrin are major contributors to the hazard. DDT hazard to *Daphnia* peaks in 2006 and 2008.

The relative hazard to algae follows a trend that is similar as for *Daphnia*: an initial increase followed by a dip in 2007, an increase again and a slight decrease in 2011 (Figure 39). Acetochlor is responsible for a major part of the ETL value (of primary concern), followed by paraquat and ametryn (of secondary concern).

Because the indicators are based on a similar kind of data, The ETL values for fish, *Daphnia* and algae can be compared among each other. The ETL values for *Daphnia* and algae are of the same order of magnitude, i.e., 3-7 from 2004 to 2011. The value for fish is more than two times lower, c. 1-3 in the same years. These observations may be explained by the fact that more insecticides than herbicides are imported in Mozambique and that in general insecticides are more toxic to aquatic invertebrates than to fish, and that herbicides are more toxic to algae than to aquatic invertebrates or fish.

The ETL for bees, and thus the relative hazard of the imported pesticides, increases steadily from 2002 to 2006 before dropping to half the peak value in 2009. From 2009 to 2011 it stays at the same level (Figure 40). The ETL is the result of a suite of different insecticides, among which imidacloprid figures most prominently (of primary concern).

The groundwater leaching potential of the active ingredients imported in Mozambique is not very high. The hazard of the majority of the imported a.i. is classified as moderate to very low. The a.i. with the highest leaching potential are methyl bromide and tebuthiuron (of primary concern).

5 Conclusions

The most significant observations according to this study are:

- The volume of pesticides imported increased almost threefold, from 670 tonnes in 2003 to 2592 tons in 2011. Agricultural production increased by 40 % from 9.9 million tonnes in 2002 to 13,9 million tonnes in 2011, whereas the agricultural area increased only by 1.4%;
- The types of pesticides imported in the country are very consistent over time. The majority of products consists of insecticides, followed by the herbicides and fungicides;
- The volume of highly hazardous products imported over time decreased and the volume of products with a (very) low hazard increased;
- Only few pesticide products with a known chronic hazard to human health were imported in the country, although carcinogenic products were imported at the rate of 100 tons per year;
- A considerable number of the pesticides imported into the country are acutely toxic to fish, aquatic invertebrates, algae and bees. However, the less hazardous pesticides represent a much higher volume of imports;
- The Environmental Toxic Load (ETL) (relative hazard corrected for surface of agricultural area) to aquatic organisms (fish, aquatic invertebrates and algae) increases from 2002 to 2010, but decreases for all three groups of species in 2011;
- Overall, the hazard of the imported pesticides is more than two times higher to aquatic invertebrates and algae than to fish;
- The ETL to bees also increases from 2002 to 2008, but is considerably lower from 2009 to 2011;
- Only few active ingredients with a very high or high leaching potential are imported in the country.

The pesticides that contributed most to the overall human health hazards and environmental hazards are given in Table 6. Active ingredients of primary or secondary concern were identified the criteria set out in §2.4. These criteria combine both potential hazard of the pesticides and imported quantities in Mozambique. Annex 5 provides the volumes of the all formulated pesticides imported in Mozambique that contain active ingredients of primary concern for all years of the period 2002-2011. These tables may be used for specific hazard reducing measures. Such tables may also be generated for pesticides of secondary concern or for any other pesticide of interest using the pivot table that is provided with the revised spreadsheet containing the Pesticide Import data.

Three things must be noted in respect to this Table: 1) pesticides with a low toxicity and a high environmental persistence are not considered. Such pesticides may even represent a bigger threat to the environment than highly toxic pesticides with a low environmental persistence; 2) the Environmental Toxic Loads are based on import data and do not account for any regional variations in use, e.g. extensive use of highly toxic pesticides in a particular area; 3) none of the classifications of pesticide active ingredients as of primary or secondary concern was based on estimated properties (see §2.1.2).

One final and general recommendation is that records of pesticide import volumes and relevant properties, including the active ingredients, can be analysed much more efficiently when the data are organised in a database environment. A database structure is needed in order to define the relations between products and compounds, and to maintain the integrity of the data that will be entered. If similar exercises are planned for Mozambique or other countries in the future, designing and setting up such a database would proof a very fruitful investment.

Table 6: Pesticides imported in Mozambique from 2002 to 2011 that are of concern in terms of potential human health and environmental hazard and annually imported quantity (for criteria, see §2.4).

Type of hazard	Pesticide active ingredient of primary concern	Pesticide active ingredient of secondary concern
Human health		
Acute (WHO classification)	Class I pesticide products containing: Abamectin Aldicarb Aluminium phoshide Fenamiphos Methomyl Mevinphos Monocrotophos Oxamyl Terbufos	Class II pesticide products containing: Ametryn DDT Lambda-cyhalothrin
Chronic	Diuron (carcinogenic) Mancozeb (carcinogenic)	Dichlorvos (carcinogenic)
Environment		
Fish	Lambda-cyhalothrin	Aluminium phoshide Chlorpyrifos Cyfluthrin Cypermethrin Endosulfan
Aquatic invertebrates	-	Chlorpyrifos Cypermethrin DDT Dichlorvos Ethion Fenvalerate Lambda-cyhalothrin Pirimiphos-methyl
Algae	Acetochlor	Ametryn Paraquat
Bees	Imidacloprid	Bendiocarb Chlorpyrifos Cyfluthrin Cypermethrin Deltamethrin Lambda-cyhalothrin Profenofos Thiamethoxam
Leaching to groundwater	Methyl bromide Tebuthiuron	Atrazine Clomazone Hexazione Imidacloprid Propoxur

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Annexes

1. Compound properties
2. Hazard to human health
3. Environmental toxic load
4. Groundwater leaching

Annex 1: Compound properties

Compound properties

Tables with the properties of the active ingredients in the imported products, 2002-2011;

1. Sources
2. Fate
3. Toxicity

Table 1.1: Source of fate and toxicity properties of the 175 active ingredients in the imported products, 2002-2011.

Source	Code (Table 2, 3)	DegT50	Koc	EC50 algae	EC50 Daphnia	EC50 fish	LD50 bee	LD50 rat
FootPrint	FP	54	138	131	145	143	135	55
FAO HHP	HHP	33						95
NMI 3	NMI	57						
Alterra ERA	ERA		1	1		1		
Mean value chemical class	CC	13	11	21	19	13	16	15
Mean value product group	PG	18	25	22	11	18	24	10

Table 1.2: Fate properties of the 175 active ingredients in the imported products, 2002-2011.

Nr.	Cas-Nr.	CompoundName	Chemical class	Product group	DegT50 (d)	source	Koc (L/kg)	source
1	94-75-7	2,4-D	aryloxyalkanoic acid	herbicide	16	NMI	88.4	FP
2	2008-39-1	2,4-D dimethylamine	aryloxyalkanoic acid	herbicide	19	CC	81.2	CC
3	71751-41-2	Abamectin	avermectin	insecticide	29	NMI	14000	FP
4	30560-19-1	Acephate	organophosphate	insecticide	3	HHP	302	FP
5	135410-20-7	Acetamiprid	neonicotinoid	insecticide	3	FP	200	FP
6	-999	Acetic acid + ammonia	organic acid	herbicide	160	PG	24379	PG
7	34256-82-1	Acetochlor	chloroacetamide	herbicide	14	FP	156	FP
8	15972-60-8	Alachlor	chloroacetamide	herbicide	14	FP	335	FP
9	116-06-3	Aldicarb	carbamate	insecticide	5	NMI	36	FP
10	67375-30-8	Alpha-cypermethrin	pyrethroid	insecticide	35	FP	57889	FP
11	20859-73-9	Aluminium phosphide	inorganic compound	insecticide	0	FP	2701	CC
12	834-12-8	Ametryn	triazine	herbicide	37	HHP	316	FP
13	129909-90-6	Amicarbazone	triazolinone	herbicide	21	FP	51.7	FP
14	33089-61-1	Amitraz	amidine	insecticide	0	HHP	1000	FP
15	1912-24-9	Atrazine	triazine	herbicide	58	NMI	100	FP
16	131860-33-8	Azoxystrobin	strobilurin	fungicide	94	NMI	589	FP
18	68038-71-1	Bacillus thuringiensis	biopesticide	insecticide	19	CC	191989	PG
19	22781-23-3	Bendiocarb	carbamate	insecticide	4	FP	385	FP
20	17804-35-2	Benomyl	benzimidazole	fungicide	0	NMI	1900	FP
21	83055-99-6	Bensulfuron-methyl	sulfonylurea	herbicide	24	FP	370	FP
22	25057-89-0	Bentazone	benzothiazinone	herbicide	37	NMI	55.3	FP
23	68359-37-5	Beta-cyfluthrin	pyrethroid	insecticide	13	FP	64300	FP
24	56073-10-0	Brodifacoum	hydrocoumarin	other	157	HHP	86200	FP
25	314-40-9	Bromacil	uracil	herbicide	60	FP	32	FP
26	1689-99-2	Bromoxynil octanoate	hydroxybenzonitrile	herbicide	1	FP	639	FP
27	41483-43-6	Bupirimate	pyrimidinol	fungicide	151	NMI	767	FP

28	33629-47-9	Butralin	dinitroaniline	herbicide	22	FP	46391	FP
29	133-06-2	Captan	phthalimide	fungicide	1	NMI	200	FP
30	63-25-2	Carbaryl	carbamate	insecticide	16	FP	300	FP
31	10605-21-7	Carbendazim	benzimidazole	fungicide	71	NMI	400	FP
32	1563-66-2	Carbofuran	carbamate	insecticide	17	NMI	22	FP
33	55285-14-8	Carbosulfan	carbamate	insecticide	21	FP	9489	FP
34	5234-68-4	Carboxin	oxathiin	fungicide	0	FP	99.4	FP
35	470-90-6	Chlorfenvinphos	organophosphate	insecticide	62	NMI	680	FP
36	99283-00-8	Chlorimuron	sulfonylurea	herbicide	17	CC	205	CC
37	1897-45-6	Chlorothalonil	chloronitrile	fungicide	14	NMI	850	FP
38	2921-88-2	Chlorpyrifos	organophosphate	insecticide	50	FP	8151	FP
39	5598-13-0	Chlorpyrifos-methyl	organophosphate	insecticide	81	NMI	4645	FP
40	8000-29-1	Citronella oil	unclassified	other	136	PG	7721846	PG
41	81777-89-1	Clomazone	isoxazolidinone	herbicide	111	NMI	300	FP
42	13822-80-5	Copper ammonium acetate	inorganic compound	fungicide	4402	CC	4657	CC
43	20427-59-2	Copper hydroxide	inorganic compound	fungicide	10000	HHP	12000	FP
44	1317-39-1	Copper oxide	inorganic compound	fungicide	10000	HHP	2701	CC
45	1332-40-7	Copper oxychloride	inorganic compound	fungicide	10000	HHP	4657	CC
46	101205-02-1	Cycloxydim	cyclohexanedione oxime	herbicide	1	NMI	59	FP
47	68359-37-5	Cyfluthrin	pyrethroid	insecticide	0	NMI	123930	FP
48	57966-95-7	cymoxanil	cyanoacetamide oxime	fungicide	1	NMI	145	FP
49	52315-07-8	Cypermethrin	pyrethroid	insecticide	60	FP	156250	FP
50	66215-27-8	Cyromazine	triazine	insecticide	32	NMI	765	FP
51	584-79-2	D-allethrin	pyrethroid	insecticide	60	HHP	2414	FP
52	533-74-4	Dazomet	dithiocarbamate	other	0	NMI	10	FP
53	50-29-3	DDT	organochlorine	insecticide	6200	FP	260324	FP
54	11-30-1	Decanol	organic alcohol	other	136	PG	7721846	PG
55	52918-63-5	Deltamethrin	pyrethroid	insecticide	30	HHP	1.0E+07	FP
56	333-41-5	Diazinon	organophosphate	insecticide	49	NMI	609	FP
57	62-73-7	Dichlorvos	organophosphate	insecticide	2	NMI	50	FP

58	7173-51-5	Didecyldimethylammonium chloride	quaternary ammonium compound	fungicide	1495	PG	1469081	ERA
59	134-62-3	Diethyltoluamide	benzamide	other	136	PG	478	FP
60	119446-68-3	Difenoconazole	triazole	insecticide	109	NMI	3760	FP
61	104653-34-1	Difethialone	coumarin anticoagulant	other	635	FP	54000000	FP
62	35367-38-5	Diflubenzuron	benzoylurea	insecticide	12	NMI	10000	FP
63	60-51-5	Dimethoate	organophosphate	insecticide	8	NMI	30.1	FP
64	330-54-1	Diuron	urea	herbicide	81	NMI	813	FP
65	115-29-7	Endosulfan	organochlorine	insecticide	50	FP	11500	FP
66	106325-08-0/133855-98-8	Epoxiconazole	triazole	fungicide	314	NMI	1802	FP
67	16672-87-0	Ethephon	ethylene generator	other	16	FP	2540	FP
68	563-12-2	Ethion	organophosphate	insecticide	90	FP	17240	FP
69	52304-36-6	Ethylbutylacetylaminopropionate	organic ester	other	136	PG	7721846	PG
70	106-93-4	Ethylene dibromide	brominated alkene	other	136	PG	7721846	PG
71	75-21-8	Ethylene oxide	organic epoxide	other	136	PG	7721846	PG
72	22224-92-6	Fenamiphos	organophosphate	insecticide	1	FP	100	FP
73	13356-08-6	Fenbutatin oxide	organotin	insecticide	95	HHP	183550	FP
74	122-14-5	Fenitrothion	organophosphate	insecticide	21	NMI	2000	FP
75	39515-41-8/64257-84-7	Fenpropathrin	pyrethroid	insecticide	28	HHP	5000	FP
76	55-38-9	Fenthion	organophosphate	insecticide	34	HHP	1500	FP
77	51630-58-1	Fenvalerate	pyrethroid	insecticide	35	HHP	5273	FP
78	120068-37-3	Fipronil	phenylpyrazole	insecticide	142	FP	577	FP
80	79241-46-6	Fluazifop-P-butyl	aryloxyphenoxypropionate	herbicide	3	NMI	3394	FP
81	69770-45-2	Flumethrin	pyrethroid	insecticide	26	CC	853297	CC
82	2164-17-2	Fluometuron	unclassified	herbicide	160	PG	24379	PG
83	69377-81-7	fluroxypyr	pyridine compound	herbicide	111	NMI	24600	FP
84	50-00-0	Formaldehyde	organic aldehyde	other	6	FP	37	FP
85	98-01-1	Furfural	heterocyclic aldehyde	other	1	FP	94.82	FP
86	1071-83-6	Glyphosate	glycine derivative	herbicide	17	NMI	1435	FP
87	135397-30-7	Halosulfuron	pyrimidinylsulfonylurea	herbicide	247	HHP	14141	PG
88	100784-20-1	Halosulfuron-methyl	pyrimidinylsulfonylurea	herbicide	14	HHP	109	FP

89	79983-71-4	Hexaconazole	triazole	fungicide	225	HHP	1040	FP
90	51235-04-2	Hexazinone	triazinone	herbicide	105	FP	54	FP
91	67485-29-4	Hydramethylnon	trifluoromethyl aminohydrazone	insecticide	7	HHP	730000	FP
92	104098-48-8	Imazapic	imidazolinone	herbicide	120	FP	137	FP
93	81334-34-1	Imazapyr	imidazolinone	herbicide	11	FP	125	FP
94	138261-41-3	Imidacloprid	neonicotinoid	insecticide	169	NMI	189	FP
95	72963-72-5	Imiprothrin	pyrethroid	insecticide	5	FP	402	FP
96	173584-44-6	Indoxacarb	oxadiazine	insecticide	17	NMI	6450	FP
97	141112-29-0	Isoxaflutole	isoxazole	insecticide	2	NMI	145	FP
98	91465-08-6	Lambda-cyhalothrin	pyrethroid	insecticide	25	FP	157000	FP
99	330-55-2	Linuron	urea	herbicide	47	NMI	739	FP
100	103055-07-8	Lufenuron	benzoylurea	insecticide	16	FP	41182	FP
101	121-75-5	Malathion	organophosphate	insecticide	1	HHP	1800	FP
102	8018-01-7	Mancozeb	dithiocarbamate	fungicide	18	HHP	998	FP
103	94-74-6	MCPA	aryloxyalkanoic acid	herbicide	22	NMI	74	FP
104	104206-82-8	Mesotrione	triketone	herbicide	16	NMI	122	FP
105	57837-19-1	Metalaxyl	phenylamide	fungicide	70	HHP	165	FP
106	70630-17-0	Metalaxyl-M	phenylamide	fungicide	216	NMI	660	FP
107	108-62-3	Metaldehyde	cyclo-octane	insecticide	8	NMI	240	FP
109	10265-92-6	Methamidophos	organophosphate	insecticide	2	NMI	1	FP
110	2032-65-7	Methiocarb	carbamate	insecticide	35	HHP	660	FP
111	16752-77-5	Methomyl	carbamate	insecticide	30	HHP	72	FP
112	74-83-9	Methyl bromide	inorganic compound	insecticide	55	FP	22	FP
113	2682-20-4	Methyl isothiazolin one	isothiozolinones	other	136	PG	7721846	PG
114	26172-55-4	Methylchoroisothiazolinone	isothiozolinones	other	136	PG	7721846	PG
115	51218-45-2	Metolachlor	chloroacetamide	herbicide	32	NMI	120	FP
116	21087-64-9	Metribuzin	triazinone	herbicide	12	FP	37.9	FP
117	74223-64-6	Metsulfuron-methyl	sulfonylurea	herbicide	10	FP	39.5	FP
118	7786-34-7	Mevinphos	organophosphate	insecticide	0	NMI	44	FP
119	-999	Mineral oil	unclassified	insecticide	132	PG	191989	PG

120	2212-67-1	Molinate	thiocarbamate	herbicide	12	HHP	190	FP
121	6923-22-4	Monocrotophos	organophosphate	insecticide	7	FP	32.8	FP
122	2163-80-6	Monosodium methyl arsenate	arsenate	herbicide	200	HHP	24379	PG
123	25154-52-3	Nonylphenol	alkylphenol	other	136	PG	7721846	PG
124	1003-07-2	Octylisothiazolinone	isothiozolinones	other	136	PG	7721846	PG
125	19666-30-9	Oxadiazon	oxidiazole	herbicide	502	FP	3200	FP
126	23135-22-0	Oxamyl	carbamate	insecticide	12	NMI	16.6	FP
127	42874-03-3	Oxyfluorfen	diphenyl ether	herbicide	35	FP	17636	FP
128	4685-14-7	Paraquat	bipyridylium	herbicide	2800	HHP	1000000	FP
129	66063-05-6	pencycuron	phenylurea	insecticide	32	HHP	6207	FP
130	40487-42-1	Pendimethalin	dinitroaniline	herbicide	90	FP	17581	FP
131	52645-53-1	Permethrin	pyrethroid	insecticide	42	HHP	100000	FP
132	26002-80-2	phenothrin	pyrethroid	insecticide	1	FP	310320	FP
133	13598-36-2	Phosphoric acid	inorganic compound	other	4402	CC	4657	CC
134	1918-02-1	Picloram	pyridine compound	herbicide	83	FP	13	FP
135	8002-09-3	Pine oil	biopesticide	herbicide	19	CC	24379	PG
136	51-03-6	Piperonyl butoxide	unclassified	insecticide	13	HHP	89125	FP
137	29232-93-7	Pirimiphos methyl	organophosphate	insecticide	22	NMI	1100	FP
138	23031-36-9	Prallethrin	pyrethroid	insecticide	26	CC	853297.5	CC
139	41198-08-7	Profenofos	organophosphate	insecticide	7	HHP	3476	FP
140	7287-19-6	Prometryn	triazine	herbicide	60	HHP	400	FP
141	709-98-8	Propanil	anilide	herbicide	0	FP	152	FP
142	2312-35-8	Propargite	sulfite ester	insecticide	56	FP	56500	FP
143	12071-83-9/9016-72-2	Propineb	dithiocarbamate	fungicide	3	FP	18	FP
144	114-26-1	Propoxur	carbamate	insecticide	35	NMI	51.72	FP
145	8003-34-7	Pyrethrins	unclassified	insecticide	132	PG	191989	PG
146	84087-01-4	Quinclorac	quinolinecarboxylic acid	herbicide	450	FP	50	FP
147	119738-06-6	Quizalofop-P-tefuryl	aryloxyphenoxypropionate	herbicide	0	FP	477	FP
150	87392-12-9/178961-20-1	S-Metolachlor	chloroacetamide	herbicide	20	NMI	2261	FP
151	168316-95-8	Spinosad	biopesticide	insecticide	31	NMI	34600	FP

152	99105-77-8	Sulcotrione	triketone	herbicide	12	NMI	36	FP
153	122836-35-5	Sulfentrazone	aryl triazolinone	herbicide	541	FP	43	FP
154	7704-34-9	Sulphur	inorganic compound	fungicide	30	FP	1950	FP
155	107534-96-3	Tebuconazole	triazole	herbicide	95	NMI	1554	FP
156	34014-18-1	Tebuthiuron	urea	herbicide	1300	HHP	80	FP
157	13071-79-9	Terbufos	organophosphate	insecticide	12	HHP	500	FP
158	5915-41-3	terbuthylazine	triazine	herbicide	105	NMI	220	FP
159	886-50-0	Terbutryn	triazine	herbicide	43	NMI	2432	FP
160	116-29-0	Tetradifon	bridged diphenyl	insecticide	112	FP	100	FP
161	7696-12-0	Tetramethrin	pyrethroid	insecticide	3	HHP	1423	FP
162	153719-23-4	Thiamethoxam	neonicotinoid	insecticide	53	NMI	56.2	FP
163	137-26-8	Thiram	dimethyldithiocarbamate	insecticide	6	NMI	670	FP
164	118712-89-3	Transfluthrin	unclassified	insecticide	132	PG	111362	PG
165	43121-43-3	Triadimefon	triazole	fungicide	26	FP	300	FP
166	55219-65-3	Triadimenol	triazole	fungicide	159	NMI	750	FP
167	52-68-6	Trichlorfon	organophosphate	insecticide	1	NMI	10	FP
170	55335-06-3	Triclopyr	pyridine compound	herbicide	35	NMI	27	FP
171	-999	Tricozene	unclassified	other	136	PG	7721846	PG
172	141517-21-7	Trifloxystrobin	strobilurin	fungicide	1	NMI	2377	FP
173	1582-09-8	Trifluralin	dinitroaniline	herbicide	181	FP	15800	FP
174	-999	Trifluthrin	pyrethroid	insecticide	26	CC	853297	CC
175	-999	Violeta Genciana	unclassified	insecticide	132	PG	191989	PG

Table 1.3: Toxicity of the 175 active ingredients in the imported products, 2002-2011.

Nr.	Compound Name	LD50 rat (mg)	source	LC50 fish (mg/L)	source	EC50 daphnia (mg/L)	source	EC50 algae (mg/L)	source	LD50 bee (µg/bee)	source
1	2,4-D	469	FP	63.4	FP	100	FP	24.2	FP	94	FP
2	2,4-D dimethylamine	585	CC	56.7	CC	145	CC	52	CC	147	CC
3	Abamectin	8.7	HHP	0.0036	FP	0.0001	FP	1.59	FP	0.0022	FP
4	Acephate	945	HHP	110	FP	67.2	FP	980	FP	1.2	FP
5	Acetamiprid	213	HHP	100	FP	49.8	FP	98.3	FP	8.09	FP
6	Acetic acid + ammonia	2782	PG	51.8	PG	92.4	PG	14.0	PG	88.6	PG
7	Acetochlor	2950	HHP	0.36	FP	8.6	FP	0.00027	FP	100	FP
8	Alachlor	930	HHP	1.8	FP	10	FP	0.966	FP	16	FP
9	Aldicarb	0.93	HHP	0.56	FP	0.42	FP	50	FP	0.09	FP
10	Alpha-cypermethrin	79	HHP	0.0028	FP	0.0003	FP	0.1	FP	0.033	FP
11	Aluminium phosphide	8.7	HHP	0.0097	FP	0.37	FP	0.058	FP	0.24	FP
12	Ametryn	110	HHP	5	FP	28	FP	0.0036	FP	100	FP
13	Amicarbazone	1015	HHP	120	FP	119	FP	14.0	PG	24.8	FP
14	Amitraz	800	HHP	0.74	FP	0.035	FP	12	FP	50	FP
15	Atrazine	2000	HHP	4.5	FP	85	FP	0.059	FP	100	FP
16	Azoxystrobin	5000	FP	0.47	FP	0.23	FP	0.36	FP	25	FP
18	Bacillus thuringiensis	3579	CC	171	PG	57	CC	45.09	PG	50	CC
19	Bendiocarb	55	HHP	1.55	FP	0.03	FP	1.71	FP	0.1	FP
20	Benomyl	10000	FP	0.17	FP	0.28	FP	2	FP	10	FP
21	Bensulfuron-methyl	5000	FP	66	FP	130	FP	0.02	FP	51.4	FP
22	Bentazone	1100	HHP	100	FP	64	FP	10.1	FP	200	FP
23	Beta-cyfluthrin	11	HHP	0.000068	FP	0.00029	FP	10	FP	0.001	FP
24	Brodifacoum	0.3	HHP	0.051	FP	0.98	FP	5.53	PG	62	PG
25	Bromacil	5200	HHP	36	FP	119	FP	0.013	FP	100	FP
26	Bromoxynil octanoate	238	FP	0.041	FP	0.046	FP	0.043	FP	100	FP

27	Bupirimate	4000	FP	1	FP	3.41	FP	1.6	FP	50	FP
28	Butralin	1049	HHP	0.37	FP	0.12	FP	0.12	FP	95.7	FP
29	Captan	2000	FP	0.186	FP	7.1	FP	1.18	FP	100	FP
30	Carbaryl	300	HHP	2.6	FP	0.0064	FP	0.6	FP	0.14	FP
31	Carbendazim	10000	FP	0.19	FP	0.15	FP	7.7	FP	50	FP
32	Carbofuran	8	HHP	0.18	FP	0.0094	FP	6.5	FP	0.036	FP
33	Carbosulfan	250	HHP	0.015	FP	0.0015	FP	47	FP	0.18	FP
34	Carboxin	2588	FP	2.3	FP	57	FP	0.48	FP	100	FP
35	Chlorfenvinphos	31	HHP	1.1	FP	0.00025	FP	1.36	FP	0.55	FP
36	Chlorimuron	4102	HHP	108	CC	140	CC	0.033	CC	38.2	CC
37	Chlorothalonil	5000	FP	0.038	FP	0.084	FP	0.21	FP	40	FP
38	Chlorpyrifos	135	HHP	0.0013	FP	0.0001	FP	0.48	FP	0.059	FP
39	Chlorpyrifos-methyl	2814	FP	0.41	FP	0.0006	FP	0.57	FP	0.11	FP
40	Citronella oil	4323	CC	2.65	CC	0.256	CC	0.17	CC	62	PG
41	Clomazone	1369	HHP	15.5	FP	12.7	FP	0.136	FP	85.3	FP
42	Copper ammonium acetate	1298	CC	1667	CC	167	CC	73.9	CC	62.1	CC
43	Copper hydroxide	1000	HHP	0.017	FP	0.038	FP	0.009	FP	44.5	FP
44	Copper oxide	300	FP	0.207	FP	0.45	FP	0.147	FP	116	FP
45	Copper oxychloride	1298	CC	1667	CC	167	CC	73.9	CC	62.1	CC
46	Cycloxydim	3900	HHP	220	FP	70.8	FP	74.9	FP	100	FP
47	Cyfluthrin	15	HHP	0.00047	FP	0.00016	FP	10	FP	0.001	FP
48	cymoxanil	1196	HHP	29	FP	27	FP	0.254	FP	85.3	FP
49	Cypermethrin	250	HHP	0.0028	FP	0.0003	FP	0.1	FP	0.02	FP
50	Cyromazine	3300	HHP	100	FP	100	FP	124	FP	186	FP
51	D-allethrin	685	HHP	19	FP	0.021	FP	8.5	CC	3.4	FP
52	Dazomet	415	FP	0.3	FP	19	FP	0.16	FP	24	FP
53	DDT	113	FP	7	FP	0.005	FP	45.1	PG	5	FP
54	Decanol	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
55	Deltamethrin	135	HHP	0.00026	FP	0.00056	FP	9.1	FP	0.0015	FP
56	Diazinon	300	HHP	3.1	FP	0.001	FP	6.4	FP	0.09	FP

57	Dichlorvos	56	HHP	0.55	FP	0.00019	FP	52.8	FP	0.29	FP
58	Didecyldimethylammonium chloride	150	HHP	1.16	FP	0.094	FP	0.66	ERA	88.3	PG
59	Diethyltoluamide	2000	HHP	71.3	FP	75	FP	5.53	PG	62	PG
60	Difenoconazole	1453	HHP	1.1	FP	0.77	FP	0.032	FP	100	FP
61	Difethialone	0.56	HHP	0.051	FP	0.0044	FP	0.18	FP	62	PG
62	Diflubenzuron	4640	FP	0.13	FP	0.0026	FP	20	FP	25	FP
63	Dimethoate	150	HHP	30.2	FP	2	FP	90.4	FP	0.12	FP
64	Diuron	3400	HHP	6.7	FP	5.7	FP	0.0027	FP	100	FP
65	Endosulfan	80	HHP	0.002	FP	0.44	FP	2.15	FP	7.81	FP
66	Epoxiconazole	3160	FP	3.14	FP	8.69	FP	1.19	FP	83	FP
67	Ethephon	1564	FP	100	FP	31.7	FP	20.9	FP	100	FP
68	Ethion	208	HHP	0.5	FP	0.000056	FP	88.3	CC	20.6	FP
69	Ethylbutylacetylaminopropionate	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
70	Ethylene dibromide	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
71	Ethylene oxide	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
72	Fenamiphos	15	HHP	0.0093	FP	0.0019	FP	3.8	FP	0.28	FP
73	Fenbutatin oxide	2630	HHP	0.00114	FP	0.048	FP	0.0036	FP	200	FP
74	Fenitrothion	503	FP	1.3	FP	0.0086	FP	1.3	FP	0.16	FP
75	Fenpropathrin	66	HHP	0.0023	FP	0.00053	FP	2	FP	0.05	FP
76	Fenthion	586	HHP	0.8	FP	0.0057	FP	1.79	FP	0.308	FP
77	Fenvalerate	450	HHP	0.0036	FP	0.00003	FP	50	FP	0.23	FP
78	Fipronil	92	HHP	0.248	FP	0.19	FP	0.068	FP	0.0042	FP
80	Fluazifop-P-butyl	2451	HHP	1.41	FP	0.62	FP	0.67	FP	200	FP
81	Flumethrin	972	CC	1.36	CC	0.0093	CC	8.47	CC	0.33	CC
82	Fluometuron	4323	CC	2.65	CC	0.26	CC	0.17	CC	88.6	PG
83	fluroxypyr	2000	FP	14.3	FP	100	FP	49.8	FP	100	FP
84	Formaldehyde	550	HHP	1.84	FP	0.43	FP	0.88	FP	62	PG
85	Furfural	65	HHP	3.06	FP	20.4	FP	5.53	PG	62	PG
86	Glyphosate	4230	HHP	38	FP	40	FP	4.4	FP	100	FP
87	Halosulfuron	8866	HHP	51.8	PG	92.4	PG	98	FP	88.6	PG

88	Halosulfuron-methyl	7758	FP	131	FP	107	FP	0.0053	FP	100	FP
89	Hexaconazole	2180	HHP	3.4	FP	2.9	FP	1.7	FP	0.1	FP
90	Hexazinone	1690	HHP	320	FP	85	FP	0.0145	FP	60	FP
91	Hydramethylnon	1200	HHP	0.16	FP	1.14	FP	0.018	FP	30	FP
92	Imazapic	5000	FP	100	FP	100	FP	0.051	FP	100	FP
93	Imazapyr	2000	FP	100	FP	100	FP	71	FP	25	FP
94	Imidacloprid	450	HHP	211	FP	85	FP	10	FP	0.0037	FP
95	Imiprothrin	900	HHP	0.038	FP	0.051	FP	3.1	FP	0.33	CC
96	Indoxacarb	286	HHP	0.65	FP	0.6	FP	0.11	FP	0.094	FP
97	Isoxaflutole	5000	FP	1.7	FP	1.5	FP	0.12	FP	100	FP
98	Lambda-cyhalothrin	56	HHP	0.00021	FP	0.00036	FP	0.3	FP	0.038	FP
99	Linuron	1146	FP	3.15	FP	0.31	FP	0.016	FP	160	FP
100	Lufenuron	2000	FP	29	FP	0.0013	FP	8.8	FP	197	FP
101	Malathion	2100	HHP	0.018	FP	0.0007	FP	13	FP	0.16	FP
102	Mancozeb	5000	FP	0.074	FP	0.073	FP	0.044	FP	141	FP
103	MCPA	700	HHP	50	FP	190	FP	79.8	FP	200	FP
104	Mesotrione	5000	FP	120	FP	900	FP	3.5	FP	11	FP
105	Metalaxyl	670	HHP	100	FP	28	FP	33	FP	200	FP
106	Metalaxyl-M	375	HHP	100	FP	100	FP	36	FP	127	FP
107	Metaldehyde	227	HHP	75	FP	78.4	FP	75.9	FP	87.5	FP
109	Methamidophos	30	HHP	25	FP	0.27	FP	178	FP	0.22	FP
110	Methiocarb	20	HHP	0.65	FP	0.008	FP	2.2	FP	0.23	FP
111	Methomyl	17	HHP	0.63	FP	0.0076	FP	100	FP	0.16	FP
112	Methyl bromide	214	FP	3.9	FP	2.6	FP	3.2	FP	50	FP
113	Methyl isothiazolin one	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
114	Methylchoroisothiazolinone	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
115	Metolachlor	2780	HHP	3.9	FP	23.5	FP	57.1	FP	110	FP
116	Metribuzin	322	HHP	74.6	FP	49	FP	0.02	FP	53	FP
117	Metsulfuron-methyl	5000	FP	150	FP	150	FP	0.045	FP	25	FP
118	Mevinphos	3.5	FP	0.012	FP	0.00016	FP	71	FP	0.027	FP

119	Mineral oil	4323	CC	2.65	CC	0.256	CC	0.17	CC	26.3	PG
120	Molinate	720	HHP	16	FP	14.9	FP	0.5	FP	11	FP
121	Monocrotophos	14	HHP	7	FP	0.023	FP	88.3	CC	0.02	FP
122	Monosodium methyl arsenate	2782	PG	51.8	PG	92.4	PG	14.0	PG	88.6	PG
123	Nonylphenol	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
124	Octylisothiazolinone	631	PG	25.2	PG	21.1	PG	5.53	PG	62	PG
125	Oxadiazon	5000	FP	1.2	FP	2.4	FP	0.004	FP	100	FP
126	Oxamyl	6	HHP	3.13	FP	0.319	FP	0.93	FP	0.38	FP
127	Oxyfluorfen	5000	FP	0.25	FP	0.72	FP	2	FP	100	FP
128	Paraquat	150	HHP	19	FP	4.4	FP	0.00023	FP	9.06	FP
129	pencycuron	5000	FP	0.3	FP	0.3	FP	0.3	FP	98.5	FP
130	Pendimethalin	1050	HHP	0.138	FP	0.28	FP	0.006	FP	100	FP
131	Permethrin	500	FP	0.0125	FP	0.0006	FP	0.0125	FP	0.029	FP
132	phenothrin	5000	FP	0.0027	FP	0.0043	FP	8.5	CC	0.33	CC
133	Phosphoric acid	454	FP	1667	CC	167	CC	73.9	CC	62.1	CC
134	Picloram	8200	HHP	8.8	FP	44.2	FP	60.2	FP	74	FP
135	Pine oil	3579	CC	51.8	PG	57	CC	14.0	PG	50.0	CC
136	Piperonyl butoxide	7220	FP	5.3	FP	0.51	FP	0.24	FP	294	FP
137	Pirimiphos methyl	1667	HHP	0.404	FP	0.00021	FP	1	FP	0.22	FP
138	Prallethrin	460	HHP	0.012	FP	0.0062	FP	8.47	CC	0.026	FP
139	Profenofos	358	HHP	0.08	FP	0.5	FP	88.3	CC	0.095	FP
140	Prometryn	3150	HHP	5.5	FP	12.66	FP	0.002	FP	99	FP
141	Propanil	1400	HHP	5.4	FP	2.39	FP	0.11	FP	94.3	FP
142	Propargite	2639	FP	0.043	FP	0.014	FP	1.08	FP	47.9	FP
143	Propineb	8500	HHP	0.4	FP	4.7	FP	2.68	FP	70	FP
144	Propoxur	50	FP	6.2	FP	0.15	FP	26.1	CC	1.35	FP
145	Pyrethrins	750	HHP	2.65	CC	0.26	CC	0.17	CC	26.3	PG
146	Quinclorac	2680	HHP	100	FP	29.8	FP	6.53	FP	181	FP
147	Quizalofop-P-tefuryl	1012	HHP	0.23	FP	1.51	FP	1.9	FP	100	FP
150	S-Metolachlor	2577	HHP	1.23	FP	26	FP	0.008	FP	85	FP

151	Spinosad	3738	HHP	30	FP	14	FP	0.09	FP	0.0029	FP
152	Sulcotrione	5000	FP	227	FP	848	FP	1.2	FP	50	FP
153	Sulfentrazone	2855	FP	93.8	FP	60.4	FP	32.8	FP	25.1	FP
154	Sulphur	2000	FP	0.063	FP	0.063	FP	0.063	FP	100	FP
155	Tebuconazole	1700	HHP	4.4	FP	2.79	FP	1.96	FP	83.05	FP
156	Tebuthiuron	644	HHP	87	FP	225	FP	0.05	FP	30	FP
157	Terbufos	2	HHP	0.004	FP	0.00031	FP	1.4	FP	4.1	FP
158	terbuthylazine	2160	HHP	2.2	FP	21.2	FP	0.012	FP	22.6	FP
159	Terbutryn	2500	FP	1.1	FP	2.66	FP	0.0024	FP	225	FP
160	Tetradifon	14700	FP	880	FP	2	FP	100	FP	11	FP
161	Tetramethrin	5000	FP	0.016	FP	0.045	FP	8.5	FP	0.16	FP
162	Thiamethoxam	1563	FP	125	FP	100	FP	100	FP	0.005	FP
163	Thiram	1800	FP	0.046	FP	0.011	FP	0.065	FP	100	FP
164	Transfluthrin	5000	FP	0.0007	FP	0.0017	FP	0.1	FP	26.3	PG
165	Triadimefon	300	FP	4.08	FP	7.16	FP	2.01	FP	25	FP
166	Triadimenol	900	HHP	21.3	FP	51	FP	9.6	FP	200	FP
167	Trichlorfon	212	FP	0.7	FP	0.00096	FP	10	FP	0.4	FP
170	Triclopyr	710	HHP	117	FP	131	FP	75.8	FP	100	FP
171	Tricozene	4323	CC	2.65	CC	0.256	CC	0.17	CC	62	PG
172	Trifloxystrobin	5000	FP	0.015	FP	0.011	FP	0.0053	FP	200	FP
173	Trifluralin	5000	FP	0.088	FP	0.245	FP	0.0122	FP	100	FP
174	Trifluthrin	972	CC	1.36	CC	0.0093	CC	8.5	CC	0.33	CC
175	Violeta Genciana	4323	CC	2.65	CC	0.256	CC	0.17	CC	26.3	PG

Annex 2 Human hazard

Tables;

1. Products with major contribution to the acute human hazard
2. Carcinogenic active ingredients
3. Mutagenic active ingredients
4. Active ingredients toxic to reproduction

Table 2.1: Products with major contribution to the acute human hazard: i.e. all Highly hazardous products (WHO class Ib) and the Moderately hazardous products (WHO class II) with a contribution > 1% of the annual volume of all products imported.

Year	Product ID	Product name	(kg)	(%)	WHO class
2002	1904	Phosgard 56% FT	1512	1.61	Ib
2002	1779	Nemacur 40% EC	500	0.53	Ib
2002	1406	Gramoxone 20% SL	8000	8.50	II
2002	2363	Tamaron 58% SL	2500	2.66	II
2002	2622	Villa Politrin 20% EC	2200	2.34	II
2002	818	Copper Oxychloride 85% WP	1500	1.59	II
2002	2535	Universal Metamidofos 58,5% SL	1500	1.59	II
2002	1827	Otrthene 75% SP	1200	1.28	II
2002	2501	Universal Cooper Oxychloride 85% WP	1000	1.06	II
2002	2563	Universal Skoffel 14.5% SL	1000	1.06	II
2002	2595	Villa MCPA 20% EC	1000	1.06	II
2003	1340	Fumaphos 56% FT	7015	1.05	Ib
2003	95	Aldicarb 15% GR	3800	0.57	Ib
2003	2376	Temik 15% GR	3200	0.48	Ib
2003	2866	Volcano Aldicarb 15% GR	2400	0.36	Ib
2003	97	Aluminium Phosphide 57% FT	2214	0.33	Ib
2003	1904	Phosgard 56% FT	2016	0.30	Ib
2003	2536	Universal Mevinfos 15% EC	1000	0.15	Ib
2003	1779	Nemacur 40% EC	750	0.11	Ib
2003	2634	Volamiphos 40% EC	750	0.11	Ib
2003	2537	Universal Monocrotofos 40% SL	500	0.07	Ib
2003	3011	Volcano Ametrin 50% EC	39920	5.96	II
2003	3172	Volcano cipermetrina 20% EC	35500	5.30	II
2003	1516	Karate 5% EC	27360	4.09	II
2003	1377	Gesapax 50% SC	25600	3.82	II
2003	883	Cipercal P 72% SL	25126	3.75	II
2003	1238	Ficam VC 80% WP	25038	3.74	II
2003	1406	Gramoxone 20% SL	21800	3.26	II
2003	98	Ametrin 50% SC	20600	3.08	II
2003	1322	Fortis Ultra 4.75% EC	14980	2.24	II
2003	3722	Volcano Methyl Bromide 100 %GA	10500	1.57	II
2003	1620	MCPA 400 SL	10100	1.51	II
2003	914	Cyperpro 72% EC	10000	1.49	II
2003	3668	Volcano MCPA 40% SL	9560	1.43	II
2003	3716	Volcamo Methamidophos 58.5% SL	9000	1.34	II
2003	2746	Volcano 90 SL	7340	1.10	II
2003	2535	Universal Metamidofos 58,5% SL	7000	1.05	II
2004	1198	Falfume 57% FT	8000	0.61	Ib
2004	1957	Quickphos 56% FD	2880	0.22	Ib
2004	1904	Phosgard 56% FT	1512	0.11	Ib
2004	2878	Volcano Alluminium Phosphide 57% FT	1000	0.08	Ib
2004	2376	Temik 15% GR	600	0.05	Ib
2004	2866	Volcano Aldicarb 15% GR	560	0.04	Ib

2004	1906	Phoskill 40% SC	500	0.04	Ib
2004	1340	Fumaphos 56% FT	346	0.03	Ib
2004	2616	Villa Platoon 31% SL	250	0.02	Ib
2004	3011	Volcano Ametrin 50% EC	118820	9.00	II
2004	3286	Volcano Endosulfan 47.5% SC	71574	5.42	II
2004	1516	Karate 5% EC	41576	3.15	II
2004	3668	Volcano MCPA 40% SL	40180	3.04	II
2004	1406	Gramoxone 20% SL	36000	2.73	II
2004	1327	Fortis Xtra 8.8% EC	31250	2.37	II
2004	1321	Fortis K 5% EC	30750	2.33	II
2004	3716	Volcamo Methamidophos 58.5% SL	30600	2.32	II
2004	4245	Zipper 20% EC	30240	2.29	II
2004	732	Ciclor 72% Ec	28050	2.12	II
2004	1455	Icon 10% WP	23345	1.77	II
2004	1377	Gesapax 50% SC	22400	1.70	II
2004	1238	Ficam VC 80% WP	17500	1.33	II
2004	3131	Volcano Cooper Oxychloride 85% WP	15500	1.17	II
2004	2746	Volcano 90 SL	15424	1.17	II
2005	2866	Volcano Aldicarb 15% GR	11400	0.71	Ib
2005	2878	Volcano Alluminium Phosphide 57% FT	3315	0.21	Ib
2005	2634	Volamiphos 40% EC	2000	0.12	Ib
2005	1340	Fumaphos 56% FT	378	0.02	Ib
2005	1904	Phosgard 56% FT	210	0.01	Ib
2005	4171	Vydate 31% SL	160	0.01	Ib
2005	139	Avi-DDT 75% WP	136000	8.49	II
2005	3011	Volcano Ametrin 50% EC	117000	7.31	II
2005	1455	Icon 10% WP	60698	3.79	II
2005	4080	Volmetra 50% SC	50800	3.17	II
2005	3716	Volcamo Methamidophos 58.5% SL	50120	3.13	II
2005	1327	Fortis Xtra 8.8% EC	43100	2.69	II
2005	1321	Fortis K 5% EC	32820	2.05	II
2005	3287	Volcano Endosulfan 50% EC	24000	1.50	II
2005	1238	Ficam VC 80% WP	20000	1.25	II
2005	3131	Volcano Cooper Oxychloride 85% WP	19500	1.22	II
2005	3172	Volcano cipermetrina 20% EC	18764	1.17	II
2005	883	Cipercal P 72% SL	18000	1.12	II
2006	1198	Falfume 57% FT	6001	0.30	Ib
2006	2878	Volcano Alluminium Phosphide 57% FT	4311	0.21	Ib
2006	2634	Volamiphos 40% EC	1025	0.05	Ib
2006	1904	Phosgard 56% FT	210	0.01	Ib
2006	1340	Fumaphos 56% FT	126	0.01	Ib
2006	1954	Provoke 75% WG	369339	18.19	II
2006	3011	Volcano Ametrin 50% EC	132880	6.54	II
2006	1321	Fortis K 5% EC	68060	3.35	II
2006	4241	Zakanaka Top 10% EC	53910	2.66	II
2006	4198	Zakanaka K 6% EC	52440	2.58	II
2006	4080	Volmetra 50% SC	41080	2.02	II
2006	1238	Ficam VC 80% WP	36200	1.78	II
2006	3668	Volcano MCPA 40% SL	31810	1.57	II
2006	3172	Volcano cipermetrina 20% EC	24500	1.21	II
2006	4219	Zakaka Pro 64,8% EC	24290	1.20	II
2006	3716	Volcamo Methamidophos 58.5% SL	23220	1.14	II
2006	3131	Volcano Cooper Oxychloride 85% WP	22750	1.12	II
2006	4134	Volquato 20% SL	20900	1.03	II
2007	1198	Falfume 57% FT	8800	0.69	Ib
2007	2878	Volcano Alluminium Phosphide 57% FT	6021	0.47	Ib
2007	2634	Volamiphos 40% EC	1500	0.12	Ib
2007	1906	Phoskill 40% SC	1200	0.09	Ib
2007	1957	Quickphos 56% FD	599	0.05	Ib
2007	1904	Phosgard 56% FT	210	0.02	Ib
2007	4171	Vydate 31% SL	120	0.01	Ib
2007	1340	Fumaphos 56% FT	42	0.00	Ib
2007	3011	Volcano Ametrin 50% EC	92140	7.21	II

2007	3668	Volcano MCPA 40% SL	54760	4.29	II
2007	3716	Volcamo Methamidophos 58.5% SL	42800	3.35	II
2007	4198	Zakanaka K 6% EC	38000	2.97	II
2007	4219	Zakaka Pro 64,8% EC	35000	2.74	II
2007	1238	Ficam VC 80% WP	32719	2.56	II
2007	1575	Lambda cyhalothrin 5% EC	30090	2.35	II
2007	882	Cyper pro 72% EC	29200	2.29	II
2007	4241	Zakanaka Top 10% EC	27880	2.18	II
2007	4134	Volquato 20% SL	21360	1.67	II
2007	3287	Volcano Endosulfan 50% EC	21000	1.64	II
2007	1321	Fortis K 5% EC	17750	1.39	II
2007	830	Courage 70% WS	17000	1.33	II
2007	4080	Volmetra 50% SC	14840	1.16	II
2007	3131	Volcano Cooper Oxychloride 85% WP	13923	1.09	II
2008	2066	Rotam Terbufos 15% GR	31000	1.53	Ib
2008	1904	Phosgard 56% FT	2079	0.10	Ib
2008	4171	Vydate 31% SL	300	0.01	Ib
2008	1954	Provoke 75% WG	513300	25.28	II
2008	1321	Fortis K 5% EC	98970	4.87	II
2008	3668	Volcano MCPA 40% SL	71100	3.50	II
2008	3011	Volcano Ametrin 50% EC	62800	3.09	II
2008	4198	Zakanaka K 6% EC	60500	2.98	II
2008	4219	Zakaka Pro 64,8% EC	45000	2.22	II
2008	3131	Volcano Cooper Oxychloride 85% WP	33010	1.63	II
2008	2746	Volcano 90 SL	27900	1.37	II
2008	4241	Zakanaka Top 10% EC	26500	1.31	II
2008	1406	Gramoxone 20% SL	21000	1.03	II
2008	3172	Volcano cipermetrina 20% EC	20500	1.01	II
2009	662	Bongo	45000	1.94	Ib
2009	2878	Volcano Alluminium Phosphide 57% FT	6510	0.28	Ib
2009	1553	Kuik	1000	0.04	Ib
2009	4171	Vydate 31% SL	480	0.02	Ib
2009	1904	Phosgard 56% FT	462	0.02	Ib
2009	3011	Volcano Ametrin 50% EC	161140	6.96	II
2009	2020	Revival 10% WP	120333	5.20	II
2009	3668	Volcano MCPA 40% SL	60360	2.61	II
2009	3131	Volcano Cooper Oxychloride 85% WP	54660	2.36	II
2009	1321	Fortis K 5% EC	42750	1.85	II
2009	4134	Volquato 20% SL	42240	1.82	II
2009	4198	Zakanaka K 6% EC	32760	1.41	II
2009	3180	Volcano D 2,4 72% SL	32000	1.38	II
2009	3716	Volcamo Methamidophos 58.5% SL	28830	1.24	II
2009	2677	Volcano 2,4 D 72% SL	28000	1.21	II
2009	4241	Zakanaka Top 10% EC	27230	1.18	II
2009	1238	Ficam VC 80% WP	26054	1.12	II
2010	2878	Volcano Alluminium Phosphide 57% FT	15519	0.58	Ib
2010	1198	Falfume 57% FT	13800	0.52	Ib
2010	1752	Moz Abamec Plus 18% EC	800	0.03	Ib
2010	1904	Phosgard 56% FT	525	0.02	Ib
2010	4171	Vydate 31% SL	500	0.02	Ib
2010	2020	Revival 10% WP	214300	8.00	II
2010	3011	Volcano Ametrin 50% EC	136060	5.08	II
2010	4241	Zakanaka Top 10% EC	63980	2.39	II
2010	3668	Volcano MCPA 40% SL	53440	2.00	II
2010	3131	Volcano Cooper Oxychloride 85% WP	52130	1.95	II
2010	2677	Volcano 2,4 D 72% SL	47000	1.76	II
2010	4219	Zakaka Pro 64,8% EC	42100	1.57	II
2010	4062	Volmet 58,5% SL	34760	1.30	II
2010	3172	Volcano cipermetrina 20% EC	32760	1.22	II
2010	1321	Fortis K 5% EC	30060	1.12	II
2011	2878	Volcano Alluminium Phosphide 57% FT	11970	0.46	Ib
2011	1904	Phosgard 56% FT	1470	0.06	Ib
2011	1756	Moz Aluminium Phosphide 56% FT	1250	0.05	Ib

2011	4171	Vydate 31% SL	300	0.01	Ib
2011	1752	Moz Abamec Plus 18% EC	240	0.01	Ib
2011	3011	Volcano Ametrin 50% EC	134900	5.20	II
2011	1203	Fendona 5% WP	75600	2.92	II
2011	3030	Volcano Copper Oxychloride 85% WP	70700	2.73	II
2011	4219	Zakaka Pro 64,8% EC	65500	2.53	II
2011	4241	Zakanaka Top 10% EC	60500	2.33	II
2011	3668	Volcano MCPA 40% SL	60200	2.32	II
2011	4198	Zakanaka K 6% EC	55300	2.13	II
2011	4134	Volquato 20% SL	35100	1.35	II
2011	1321	Fortis K 5% EC	35000	1.35	II
2011	2677	Volcano 2,4 D 72% SL	32600	1.26	II
2011	3172	Volcano cipermetrina 20% EC	30450	1.17	II

Table 2.2: Carcinogenic active ingredients with the contribution to the annual volume of active ingredients imported (in %).

Year	Compound ID	Compound name	(kg)	(%)
2002	102	Mancozeb	2000	10.7
2002	57	Dichlorvos	461	2.46
2002	131	Permethrin	24	0.13
2003	64	Diuron	20400	6.53
2003	102	Mancozeb	15248	4.88
2003	57	Dichlorvos	1641	0.53
2003	37	Chlorothalonil	400	0.13
2003	8	Alachlor	384	0.12
2003	131	Permethrin	18	0.01
2004	102	Mancozeb	44848	7.72
2004	64	Diuron	44672	7.69
2004	57	Dichlorvos	6162	1.06
2004	37	Chlorothalonil	1537	0.26
2004	8	Alachlor	384	0.07
2004	131	Permethrin	28	0.005
2005	64	Diuron	40976	5.90
2005	102	Mancozeb	20080	2.89
2005	57	Dichlorvos	1513	0.22
2005	37	Chlorothalonil	1382	0.20
2005	131	Permethrin	40	0.01
2006	64	Diuron	40312	4.49
2006	102	Mancozeb	23666	2.63
2006	57	Dichlorvos	5323	0.59
2006	8	Alachlor	1260	0.14
2006	37	Chlorothalonil	691	0.08
2006	131	Permethrin	28	0.003
2007	64	Diuron	33568	6.05
2007	102	Mancozeb	30936	5.57
2007	64	Diuron	23072	4.16
2007	102	Mancozeb	15782	2.84
2007	57	Dichlorvos	6376	1.15
2007	57	Dichlorvos	3551	0.64
2007	8	Alachlor	1800	0.32
2007	125	Oxadiazon	950	0.17
2007	37	Chlorothalonil	850	0.15
2007	131	Permethrin	246	0.04
2007	131	Permethrin	34	0.01
2007	30	Carbaryl	20	0.004
2009	64	Diuron	48899	5.69
2009	102	Mancozeb	30003	3.49
2009	125	Oxadiazon	5000	0.58
2009	57	Dichlorvos	2433	0.28
2009	37	Chlorothalonil	1000	0.12
2009	97	Isoxaflutole	750	0.09
2009	131	Permethrin	49	0.01
2009	84	Formaldehyde	13	0.00
2010	102	Mancozeb	53574	5.58
2010	64	Diuron	37889	3.95
2010	37	Chlorothalonil	5500	0.57
2010	57	Dichlorvos	2921	0.30
2010	97	Isoxaflutole	1920	0.20
2010	127	Oxyfluorfen	216	0.02
2010	131	Permethrin	114	0.01
2010	84	Formaldehyde	50	0.01
2010	30	Carbaryl	8	0.001
2011	102	Mancozeb	61075	6.48

2011	64	Diuron	43312	4.60
2011	57	Dichlorvos	5421	0.58
2011	84	Formaldehyde	1074	0.11
2011	37	Chlorothalonil	750	0.08
2011	131	Permethrin	84	0.01
2011	30	Carbaryl	84	0.01
2011	97	Isoxaflutole	15	0.002

Table 2.3: Mutagenic active ingredients with the contribution to the annual volume of active ingredients imported (in %).

Year	Compound ID	Compound name	(kg)	(%)
2004	20	Benomyl	735	0.13
2005	20	Benomyl	200	0.029
2006	20	Benomyl	200	0.022
2007	31	Carbendazim	1.3	0.0002
2008	31	Carbendazim	5	0.001
2009	20	Benomyl	500	0.058
2009	31	Carbendazim	54	0.006
2010	20	Benomyl	2800	0.29
2010	31	Carbendazim	0.4	0.00004
2011	31	Carbendazim	0.6	0.0001

Table 2.4: Active ingredients toxic to reproduction with the contribution to the annual volume of active ingredients imported (in %).

Year	Compound ID	Compound name	(kg)	(%)
2004	20	Benomyl	735	0.13
2005	20	Benomyl	200	0.029
2006	20	Benomyl	200	0.022
2007	31	Carbendazim	1.3	0.0002
2008	31	Carbendazim	5	0.001
2009	20	Benomyl	500	0.058
2009	31	Carbendazim	54	0.006
2010	20	Benomyl	2800	0.29
2010	31	Carbendazim	0.4	0.00004
2011	31	Carbendazim	0.6	0.0001

Annex 3 Environmental toxic Loads

Tables;

1. Active ingredients with the major contribution to the annual ETL for fish
2. Active ingredients with the major contribution to the annual ETL for Daphnia
3. Active ingredients with the major contribution to the annual ETL for algae
4. Active ingredients with the major contribution to the annual ETL for bees

Table 3.1: Active ingredients with the major contribution to the annual ETL for fish (i.e. > 0.5 %).

Year	RankNr	Compound Nr.	Compound name	(kg)	(%)
2002	1	38	Chlorpyrifos	240	30.1
2002	2	49	Cypermethrin	440	25.6
2002	3	11	Aluminium phosphide	847	14.2
2002	4	47	Cyfluthrin	37	12.7
2002	5	65	Endosulfan	70	5.7
2002	6	102	Mancozeb	2000	4.4
2002	7	72	Fenamiphos	200	3.5
2002	8	154	Sulphur	800	2.1
2002	9	142	Propargite	240	0.9
2003	1	98	Lambda-cyhalothrin	2158	56.8
2003	2	49	Cypermethrin	12317	24.3
2003	3	38	Chlorpyrifos	1699	7.2
2003	4	11	Aluminium phosphide	6319	3.6
2003	5	23	Beta-cyfluthrin	30	2.4
2003	6	139	Profenofos	22226	1.5
2003	7	102	Mancozeb	15248	1.1
2004	1	98	Lambda-cyhalothrin	7992	50.1
2004	2	65	Endosulfan	34103	22.4
2004	3	38	Chlorpyrifos	18078	18.3
2004	4	49	Cypermethrin	12034	5.7
2004	5	11	Aluminium phosphide	7783	1.1
2004	6	102	Mancozeb	44848	0.8
2004	7	23	Beta-cyfluthrin	40	0.8
2005	1	98	Lambda-cyhalothrin	12377	80.8
2005	2	65	Endosulfan	12140	8.3
2005	3	49	Cypermethrin	6813	3.3
2005	4	23	Beta-cyfluthrin	111	2.2
2005	5	38	Chlorpyrifos	1200	1.3
2005	6	77	Fenvalerate	3050	1.2
2005	7	73	Fenbutatin oxide	550	0.7
2006	1	98	Lambda-cyhalothrin	11698	84.4
2006	2	65	Endosulfan	7885	6.0
2006	3	49	Cypermethrin	7857	4.3
2006	4	38	Chlorpyrifos	1536	1.8
2006	5	11	Aluminium phosphide	6066	0.9
2006	6	139	Profenofos	27471	0.5
2006	7	23	Beta-cyfluthrin	23	0.5
2007	1	98	Lambda-cyhalothrin	8216	67.2
2007	2	65	Endosulfan	10588	9.1
2007	3	55	Deltamethrin	1204	7.9
2007	4	38	Chlorpyrifos	3056	4.0
2007	5	49	Cypermethrin	6174	3.8
2007	6	77	Fenvalerate	5439	2.6
2007	7	11	Aluminium phosphide	8925	1.6
2007	8	73	Fenbutatin oxide	605	0.9

2007	9	139	Profenofos	39720	0.9
2007	10	102	Mancozeb	30936	0.7
2007	11	23	Beta-cyfluthrin	23	0.6
2008	1	98	Lambda-cyhalothrin	13263	81.4
2008	2	55	Deltamethrin	1579	7.8
2008	3	38	Chlorpyrifos	3223	3.2
2008	4	49	Cypermethrin	5450	2.5
2008	5	157	Terbufos	4650	1.5
2008	6	65	Endosulfan	1050	0.7
2009	1	98	Lambda-cyhalothrin	20403	89.4
2009	2	38	Chlorpyrifos	4366	3.1
2009	3	157	Terbufos	6750	1.6
2009	4	49	Cypermethrin	4139	1.4
2009	5	77	Fenvalerate	4000	1.0
2009	6	73	Fenbutatin oxide	1164	0.9
2009	7	55	Deltamethrin	189	0.7
2010	1	98	Lambda-cyhalothrin	30610	89.4
2010	2	38	Chlorpyrifos	11772	5.6
2010	3	49	Cypermethrin	8335	1.8
2010	4	11	Aluminium phosphide	17006	1.1
2011	1	98	Lambda-cyhalothrin	12760	83.4
2011	2	38	Chlorpyrifos	4279	4.5
2011	3	49	Cypermethrin	6926	3.4
2011	4	10	Alpha-cypermethrin	3780	1.9
2011	5	65	Endosulfan	2548	1.7
2011	6	11	Aluminium phosphide	8346	1.2
2011	7	102	Mancozeb	61075	1.1
2011	8	139	Profenofos	55130	0.9
2011	9	55	Deltamethrin	145	0.8

Table 3.2: Active ingredients with the major contribution to the annual ETL for Daphnia (i.e. > 0.5 %).

Year	RankNr	Compound Nr.	Compound name	(kg)	(%)
2002	1	57	Dichlorvos	461	32.2
2002	2	38	Chlorpyrifos	240	31.8
2002	3	49	Cypermethrin	440	19.5
2002	4	137	Pirimiphos methyl	96	6.1
2002	5	39	Chlorpyrifos-methyl	200	4.4
2002	6	47	Cyfluthrin	37	3.0
2002	7	72	Fenamiphos	200	1.4
2002	8	131	Permethrin	24	0.5
2003	1	49	Cypermethrin	12317	43.9
2003	2	38	Chlorpyrifos	1699	18.2
2003	3	137	Pirimiphos methyl	3069	15.6
2003	4	57	Dichlorvos	1641	9.2
2003	5	98	Lambda-cyhalothrin	2158	6.4
2003	6	77	Fenvalerate	76	2.7
2003	7	118	Mevinphos	150	1.0
2003	8	19	Bendiocarb	20030	0.7
2003	9	33	Carbosulfan	835	0.6
2004	1	38	Chlorpyrifos	18078	60.4
2004	2	49	Cypermethrin	12034	13.4
2004	3	57	Dichlorvos	6162	10.8
2004	4	98	Lambda-cyhalothrin	7992	7.4
2004	5	137	Pirimiphos methyl	4094	6.5
2005	1	77	Fenvalerate	3050	38.6
2005	2	68	Ethion	2525	17.1
2005	3	98	Lambda-cyhalothrin	12377	13.1
2005	4	49	Cypermethrin	6813	8.6
2005	5	53	DDT	102000	7.7
2005	6	137	Pirimiphos methyl	2876	5.2
2005	7	38	Chlorpyrifos	1200	4.6
2005	8	57	Dichlorvos	1513	3.0
2005	9	35	Chlorfenvinphos	600	0.9
2006	1	53	DDT	285929	26.5
2006	2	68	Ethion	2525	20.9
2006	3	98	Lambda-cyhalothrin	11698	15.1
2006	4	57	Dichlorvos	5323	13.0
2006	5	49	Cypermethrin	7857	12.1
2006	6	38	Chlorpyrifos	1536	7.1
2006	7	77	Fenvalerate	100	1.5
2006	8	137	Pirimiphos methyl	538	1.2
2006	9	35	Chlorfenvinphos	636	1.2
2007	1	77	Fenvalerate	5439	51.5
2007	2	68	Ethion	3030	15.4
2007	3	57	Dichlorvos	6376	9.5
2007	4	38	Chlorpyrifos	3056	8.7
2007	5	98	Lambda-cyhalothrin	8216	6.5
2007	6	49	Cypermethrin	6174	5.8
2007	7	137	Pirimiphos methyl	857	1.2
2007	8	55	Deltamethrin	1204	0.6
2008	1	53	DDT	384975	31.4
2008	2	98	Lambda-cyhalothrin	13263	15.0
2008	3	38	Chlorpyrifos	3223	13.2
2008	4	77	Fenvalerate	800	10.9
2008	5	57	Dichlorvos	3551	7.6
2008	6	49	Cypermethrin	5450	7.4
2008	7	157	Terbufos	4650	6.1
2008	8	137	Pirimiphos methyl	2490	4.8
2008	9	55	Deltamethrin	1579	1.2

2008	10	35	Chlorfenvinphos	375	0.6
2009	1	77	Fenvalerate	4000	45.5
2009	2	98	Lambda-cyhalothrin	20403	19.4
2009	3	38	Chlorpyrifos	4366	14.9
2009	4	157	Terbufos	6750	7.4
2009	5	49	Cypermethrin	4139	4.7
2009	6	57	Dichlorvos	2433	4.4
2009	7	137	Pirimiphos methyl	1010	1.6
2010	1	38	Chlorpyrifos	11772	42.5
2010	2	98	Lambda-cyhalothrin	30610	30.7
2010	3	49	Cypermethrin	8335	10.0
2010	4	77	Fenvalerate	500	6.0
2010	5	57	Dichlorvos	2921	5.5
2010	6	137	Pirimiphos methyl	1966	3.4
2010	7	3	Abamectin	189	0.7
2011	1	38	Chlorpyrifos	4279	27.9
2011	2	98	Lambda-cyhalothrin	12760	23.1
2011	3	57	Dichlorvos	5421	18.6
2011	4	49	Cypermethrin	6926	15.1
2011	5	10	Alpha-cypermethrin	3780	8.2
2011	6	137	Pirimiphos methyl	1394	4.3
2011	7	3	Abamectin	115	0.8
2011	8	102	Mancozeb	61075	0.5

Table 3.3: Active ingredients with the major contribution to the annual ETL for algae (i.e. > 0.5 %).

Year	RankNr	Compound Nr.	Compound name	(kg)	(%)
2002	1	128	Paraquat	1745	98.5
2002	2	102	Mancozeb	2000	0.6
2003	1	7	Acetochlor	14652	56.5
2003	2	128	Paraquat	4721	21.4
2003	3	12	Ametryn	43060	12.5
2003	4	64	Diuron	20400	7.9
2004	1	7	Acetochlor	33768	63.0
2004	2	128	Paraquat	7418	16.3
2004	3	12	Ametryn	70610	9.9
2004	4	64	Diuron	44672	8.3
2004	5	159	Terbutryn	6203	1.3
2004	6	102	Mancozeb	44848	0.5
2005	1	7	Acetochlor	59061	76.0
2005	2	128	Paraquat	5377	8.1
2005	3	12	Ametryn	82480	8.0
2005	4	64	Diuron	40976	5.3
2005	5	140	Prometryn	5280	0.9
2005	6	130	Pendimethalin	15170	0.9
2006	1	7	Acetochlor	41454	68.7
2006	2	128	Paraquat	6604	12.8
2006	3	12	Ametryn	76710	9.5
2006	4	64	Diuron	40312	6.7
2006	5	130	Pendimethalin	14220	1.1
2007	1	7	Acetochlor	30591	71.3
2007	2	128	Paraquat	4272	11.7
2007	3	12	Ametryn	51060	8.9
2007	4	64	Diuron	23072	5.4
2007	5	130	Pendimethalin	11240	1.2
2008	1	7	Acetochlor	72239	84.3
2008	2	128	Paraquat	4600	6.3
2008	3	64	Diuron	33568	3.9
2008	4	12	Ametryn	41040	3.6
2008	5	130	Pendimethalin	26130	1.4
2009	1	7	Acetochlor	66996	74.5
2009	2	128	Paraquat	8448	11.0
2009	3	12	Ametryn	80570	6.7
2009	4	64	Diuron	48899	5.4
2009	5	130	Pendimethalin	20090	1.0
2010	1	7	Acetochlor	80856	81.8
2010	2	128	Paraquat	4540	5.4
2010	3	12	Ametryn	68030	5.2
2010	4	64	Diuron	37889	3.8
2010	5	130	Pendimethalin	61120	2.8
2011	1	7	Acetochlor	57456	74.6
2011	2	128	Paraquat	7020	10.7
2011	3	12	Ametryn	67450	6.6
2011	4	64	Diuron	43312	5.6
2011	5	130	Pendimethalin	27180	1.6

Table 3.4: Active ingredients with the major contribution to the annual ETL for bees (i.e. > 0.5 %)

Year	RankNr	Compound Nr.	Compound name	(kg)	(%)
2002	1	94	Imidacloprid	269	46.0
2002	2	47	Cyfluthrin	37	23.3
2002	3	49	Cypermethrin	440	13.9
2002	4	109	Methamidophos	2340	6.7
2002	5	38	Chlorpyrifos	240	2.6
2002	6	11	Aluminium phosphide	847	2.2
2002	7	39	Chlorpyrifos-methyl	200	1.2
2002	8	57	Dichlorvos	461	1.0
2002	9	32	Carbofuran	50	0.9
2002	10	131	Permethrin	24	0.5
2003	1	49	Cypermethrin	12317	41.6
2003	2	139	Profenofos	22226	15.8
2003	3	19	Bendiocarb	20030	13.5
2003	4	162	Thiamethoxam	521	7.0
2003	5	109	Methamidophos	12578	3.9
2003	6	98	Lambda-cyhalothrin	2158	3.8
2003	7	47	Cyfluthrin	41	2.8
2003	8	23	Beta-cyfluthrin	30	2.0
2003	9	38	Chlorpyrifos	1699	1.9
2003	10	11	Aluminium phosphide	6319	1.8
2003	11	9	Aldicarb	1410	1.1
2003	12	137	Pirimiphos methyl	3069	0.9
2003	13	3	Abamectin	23	0.7
2003	14	121	Monocrotophos	200	0.7
2004	1	49	Cypermethrin	12034	29.4
2004	2	38	Chlorpyrifos	18078	15.0
2004	3	162	Thiamethoxam	1488	14.5
2004	4	98	Lambda-cyhalothrin	7992	10.3
2004	5	19	Bendiocarb	14000	6.8
2004	6	94	Imidacloprid	332	4.4
2004	7	109	Methamidophos	19656	4.4
2004	8	139	Profenofos	5150	2.6
2004	9	47	Cyfluthrin	54	2.6
2004	10	23	Beta-cyfluthrin	40	2.0
2004	11	11	Aluminium phosphide	7783	1.6
2004	12	3	Abamectin	58	1.3
2004	13	57	Dichlorvos	6162	1.0
2004	14	137	Pirimiphos methyl	4094	0.9
2004	15	63	Dimethoate	1440	0.6
2004	16	89	Hexaconazole	1147	0.6
2005	1	94	Imidacloprid	2161	25.0
2005	2	49	Cypermethrin	6813	14.6
2005	3	98	Lambda-cyhalothrin	12377	13.9
2005	4	139	Profenofos	19977	9.0
2005	5	162	Thiamethoxam	910	7.8
2005	6	19	Bendiocarb	16000	6.8
2005	7	109	Methamidophos	35024	6.8
2005	8	23	Beta-cyfluthrin	111	4.8
2005	9	47	Cyfluthrin	90	3.9
2005	10	78	Fipronil	120	1.2
2005	11	53	DDT	102000	0.9
2005	12	38	Chlorpyrifos	1200	0.9
2005	13	9	Aldicarb	1710	0.8
2005	14	89	Hexaconazole	1733	0.7

2005	15	77	Fenvalerate	3050	0.6
2005	16	137	Pirimiphos methyl	2876	0.6
2006	1	94	Imidacloprid	12367	66.9
2006	2	49	Cypermethrin	7857	7.9
2006	3	98	Lambda-cyhalothrin	11698	6.2
2006	4	19	Bendiocarb	28960	5.8
2006	5	139	Profenofos	27471	5.8
2006	6	109	Methamidophos	14110	1.3
2006	7	53	DDT	285929	1.1
2006	8	47	Cyfluthrin	46	0.9
2006	9	89	Hexaconazole	3464	0.7
2006	10	78	Fipronil	120	0.6
2006	11	38	Chlorpyrifos	1536	0.5
2006	12	11	Aluminium phosphide	6066	0.5
2007	1	94	Imidacloprid	12924	59.1
2007	2	55	Deltamethrin	1204	13.6
2007	3	139	Profenofos	39720	7.1
2007	4	49	Cypermethrin	6174	5.2
2007	5	19	Bendiocarb	26175	4.4
2007	6	98	Lambda-cyhalothrin	8216	3.7
2007	7	109	Methamidophos	33521	2.6
2007	8	38	Chlorpyrifos	3056	0.9
2007	9	11	Aluminium phosphide	8925	0.6
2008	1	94	Imidacloprid	14802	61.3
2008	2	55	Deltamethrin	1579	16.1
2008	3	98	Lambda-cyhalothrin	13263	5.3
2008	4	139	Profenofos	29802	4.8
2008	5	49	Cypermethrin	5450	4.2
2008	6	19	Bendiocarb	10816	1.7
2008	7	53	DDT	384975	1.2
2008	8	109	Methamidophos	12969	0.9
2008	9	38	Chlorpyrifos	3223	0.8
2008	10	47	Cyfluthrin	47	0.7
2008	11	3	Abamectin	79	0.6
2009	1	94	Imidacloprid	5955	44.1
2009	2	98	Lambda-cyhalothrin	20403	14.7
2009	3	19	Bendiocarb	21243	5.8
2009	4	49	Cypermethrin	4139	5.7
2009	5	78	Fipronil	840	5.5
2009	6	47	Cyfluthrin	188	5.2
2009	7	139	Profenofos	14256	4.1
2009	8	55	Deltamethrin	189	3.4
2009	9	109	Methamidophos	23886	3.0
2009	10	162	Thiamethoxam	465	2.5
2009	11	38	Chlorpyrifos	4366	2.0
2009	12	3	Abamectin	82	1.0
2010	1	94	Imidacloprid	3781	26.2
2010	2	98	Lambda-cyhalothrin	30610	20.6
2010	3	49	Cypermethrin	8335	10.7
2010	4	78	Fipronil	1586	9.7
2010	5	139	Profenofos	27170	7.3
2010	6	38	Chlorpyrifos	11772	5.1
2010	7	162	Thiamethoxam	950	4.9
2010	8	47	Cyfluthrin	166	4.3
2010	9	109	Methamidophos	20335	2.4
2010	10	3	Abamectin	189	2.2
2010	11	55	Deltamethrin	120	2.1
2010	12	11	Aluminium phosphide	17006	1.8
2010	13	19	Bendiocarb	4648	1.2
2011	1	94	Imidacloprid	3553	29.1
2011	2	139	Profenofos	55130	17.6
2011	3	162	Thiamethoxam	1917	11.6
2011	4	49	Cypermethrin	6926	10.5

2011	5	98	Lambda-cyhalothrin	12760	10.2
2011	6	19	Bendiocarb	11648	3.5
2011	7	10	Alpha-cypermethrin	3780	3.5
2011	8	47	Cyfluthrin	101	3.1
2011	9	55	Deltamethrin	145	2.9
2011	10	38	Chlorpyrifos	4279	2.2
2011	11	3	Abamectin	115	1.6
2011	12	11	Aluminium phosphide	8346	1.1
2011	13	109	Methamidophos	7634	1.1
2011	14	57	Dichlorvos	5421	0.6
2011	15	151	Spinosad	52	0.5

Annex 4: Groundwater leaching

Tables;

1. GUS and groundwater leaching potential class of the active ingredients
2. Active ingredients with the Very high and High groundwater leaching potential class.

Table 4.1: The GUS and groundwater leaching potential class of the active ingredients in the imported products.

Nr.	Compound Name	GUS	Class
1	2,4-D	2.5	3
2	2,4-D dimethylamine	3.0	3
3	Abamectin	-0.2	1
4	Acephate	0.73	1
5	Acetamiprid	0.81	1
6	Acetic acid + ammonia	-0.3	1
7	Acetochlor	2.1	3
8	Alachlor	1.7	2
9	Aldicarb	1.7	2
10	Alpha-cypermethrin	-1.2	1
11	Aluminium phosphide	-2.8	1
12	Ametryn	2.4	3
13	Amicarbazone	3.3	4
14	Amitraz	-5	1
15	Atrazine	3.5	4
16	Azoxystrobin	2.4	3
18	Bacillus thuringiensis	-1.3	1
19	Bendiocarb	0.85	1
20	Benomyl	-3.6	1
21	Bensulfuron-methyl	2.0	2
22	Bentazone	3.5	4
23	Beta-cyfluthrin	-0.9	1
24	Brodifacoum	-1.5	1
25	Bromacil	4.4	5
26	Bromoxynil octanoate	0	1
27	Bupirimate	2.4	3
28	Butralin	-0.9	1
29	Captan	0	1
30	Carbaryl	1.8	2
31	Carbendazim	2.6	3
32	Carbofuran	3.3	4
33	Carbosulfan	0.030	1
34	Carboxin	-10.0	1
35	Chlorfenvinphos	2.1	3
36	Chlorimuron	2.4	3
37	Chlorothalonil	1.2	2
38	Chlorpyrifos	0.15	1
39	Chlorpyrifos-methyl	0.64	1

40	Citronella oil	-5.7	1
41	Clomazone	3.1	4
42	Copper ammonium acetate	2.1	3
43	Copper hydroxide	-0.3	1
44	Copper oxide	2.3	3
45	Copper oxychloride	2.3	3
46	Cycloxydim	0	1
47	Cyfluthrin	0.33	1
48	cymoxanil	0	1
49	Cypermethrin	-2.1	1
50	Cyromazine	1.7	2
51	D-allethrin	1.5	2
52	Dazomet	-15	1
53	DDT	-4.5	1
54	Decanol	-5.7	1
55	Deltamethrin	-4.4	1
56	Diazinon	2.1	3
57	Dichlorvos	0.69	1
58	Didecyldimethylammonium chloride	-6.9	1
59	Diethyltoluamide	3.3	4
60	Difenoconazole	0.87	1
61	Difethialone	-10.5	1
62	Diflubenzuron	0	1
63	Dimethoate	2.3	3
64	Diuron	2.1	3
65	Endosulfan	-0.1	1
66	Epoxiconazole	1.9	2
67	Ethephon	0.72	1
68	Ethion	0	1
69	Ethylbutylacetylaminopropionate	-5.7	1
70	Ethylene dibromide	-5.7	1
71	Ethylene oxide	-5.7	1
72	Fenamiphos	0	1
73	Fenbutatin oxide	-2.5	1
74	Fenitrothion	0.92	1
75	Fenpropathrin	0.44	1
76	Fenthion	1.3	2
77	Fenvalerate	0.43	1
78	Fipronil	2.7	3
80	Fluazifop-P-butyl	0.22	1
81	Flumethrin	-2.4	1
82	Fluometuron	-0.3	1
83	fluroxypyr	-0.8	1
84	Formaldehyde	1.9	2
85	Furfural	0	1
86	Glyphosate	1.0	2
87	Halosulfuron	-0.4	1
88	Halosulfuron-methyl	2.2	3
89	Hexaconazole	2.3	3
90	Hexazinone	4.6	5
91	Hydramethylnon	-1.6	1

92	Imazapic	3.9	4
93	Imazapyr	2.0	2
94	Imidacloprid	3.8	4
95	Imiprothrin	0.98	1
96	Indoxacarb	0.23	1
97	Isoxaflutole	0.55	1
98	Lambda-cyhalothrin	-1.7	1
99	Linuron	1.9	2
100	Lufenuron	-0.7	1
101	Malathion	0	1
102	Mancozeb	1.3	2
103	MCPA	2.9	3
104	Mesotrione	2.3	3
105	Metalaxyl	3.3	4
106	Metalaxyl-M	2.8	3
107	Metaldehyde	1.5	2
109	Methamidophos	1.2	2
110	Methiocarb	1.8	2
111	Methomyl	3.2	4
112	Methyl bromide	4.6	5
113	Methyl isothiazolin one	-5.7	1
114	Methylchoroisothiazolinone	-5.7	1
115	Metolachlor	2.9	3
116	Metribuzin	2.6	3
117	Metsulfuron-methyl	2.4	3
118	Mevinphos	-11.8	1
119	Mineral oil	-2.2	1
120	Molinate	1.9	2
121	Monocrotophos	2.3	3
122	Monosodium methyl arsenate	-0.3	1
123	Nonylphenol	-5.7	1
124	Octylisothiazolinone	-5.7	1
125	Oxadiazon	1.3	2
126	Oxamyl	3.0	4
127	Oxyfluorfen	-0.4	1
128	Paraquat	-6.9	1
129	pencycuron	0.31	1
130	Pendimethalin	-0.5	1
131	Permethrin	-1.6	1
132	phenothrin	0	1
133	Phosphoric acid	2.1	3
134	Picloram	5.5	5
135	Pine oil	-0.2	1
136	Piperonyl butoxide	-1.1	1
137	Pirimiphos methyl	1.3	2
138	Prallethrin	-2.4	1
139	Profenofos	0.59	1
140	Prometryn	2.5	3
141	Propanil	-9.1	1
142	Propargite	-1.3	1
143	Propineb	1.3	2

144	Propoxur	3.9	4
145	Pyrethrins	-2.2	1
146	Quinclorac	6.1	5
147	Quizalofop-P-tefuryl	-6.6	1
150	S-Metolachlor	0.84	1
151	Spinosad	-0.8	1
152	Sulcotrione	2.6	3
153	Sulfentrazone	6.5	5
154	Sulphur	1.0	2
155	Tebuconazole	1.6	2
156	Tebuthiuron	6.5	5
157	Terbufos	1.4	2
158	terbuthylazine	3.4	4
159	Terbutryn	1.0	2
160	Tetradifon	4.1	5
161	Tetramethrin	0.40	1
162	Thiamethoxam	3.9	4
163	Thiram	0.91	1
164	Transfluthrin	-2.2	1
165	Triadimefon	2.2	3
166	Triadimenol	2.5	3
167	Trichlorfon	0	1
170	Triclopyr	4.0	4
171	Tricozene	-5.7	1
172	Trifloxystrobin	0	1
173	Trifluralin	-0.4	1
174	Trifluthrin	-2.4	1
175	Violeta Genciana	-2.2	1

Table 4.2: Active ingredients in the Very high (5) and High (4) groundwater leaching potential class with a contribution to the annual volume of Active ingredients imported > 0.01 %.

Year	Compound number	Compound name	Class number	Volume (kg ai)	(%)
2002	144	Propoxur	4	461	2.46
	94	Imidacloprid		269	1.44
	32	Carbofuran		50	0.27
2003	112	Methyl bromide	5	10290	3.29
	156	Tebuthiuron		2840	0.91
	25	Bromacil		1000	0.32
	90	Hexazinone		360	0.12
	144	Propoxur	4	641	0.21
	162	Thiamethoxam		521	0.17
	170	Triclopyr		96	0.03
2004	112	Methyl bromide	5	12740	2.19
	162	Thiamethoxam	4	1488	0.26
	144	Propoxur		1162	0.20
	15	Atrazine		713	0.12
	94	Imidacloprid		332	0.06
	126	Oxamyl		78	0.01
	158	terbuthylazine		75	0.01
2005	112	Methyl bromide	5	10290	1.48
	90	Hexazinone		3418	0.49
	156	Tebuthiuron		2950	0.42
	25	Bromacil		110	0.02
	15	Atrazine	4	13268	1.91
	94	Imidacloprid		2161	0.31
	170	Triclopyr		1795	0.26
	144	Propoxur		1513	0.22
	162	Thiamethoxam		910	0.13
	41	Clomazone		336	0.05
	158	terbuthylazine		175	0.03
2006	156	Tebuthiuron	5	5450	0.61
	90	Hexazinone		4046	0.45
	94	Imidacloprid	4	12367	1.38
	15	Atrazine		11020	1.23
	170	Triclopyr		2563	0.29
	144	Propoxur		1833	0.20
	105	Metalaxyl		332	0.04
	158	terbuthylazine		150	0.02
2007	156	Tebuthiuron	5	5590	1.01
	90	Hexazinone		3110	0.56
	94	Imidacloprid	4	12924	2.33
	15	Atrazine		3823	0.69
	170	Triclopyr		2678	0.48
	22	Bentazone		2208	0.40
	105	Metalaxyl		646	0.12
	144	Propoxur		364	0.07
2008	156	Tebuthiuron	5	3935	0.40
	90	Hexazinone		154	0.02
	94	Imidacloprid	4	14802	1.49
	41	Clomazone		4704	0.47
	170	Triclopyr		3754	0.38
	144	Propoxur		367	0.04
	15	Atrazine		113	0.01
2009	156	Tebuthiuron	5	10855	1.26
	90	Hexazinone		5674	0.66
	134	Picloram		480	0.06
	146	Quinclorac		315	0.04
	25	Bromacil		215	0.02
	41	Clomazone	4	13056	1.52
	94	Imidacloprid		5955	0.69

	170	Triclopyr		3955	0.46
	144	Propoxur		1869	0.22
	92	Imazapic		1050	0.12
	111	Methomyl		900	0.10
	13	Amicarbazone		875	0.10
	22	Bentazone		864	0.10
	105	Metalaxyl		696	0.08
	162	Thiamethoxam		465	0.05
	15	Atrazine		409	0.05
	126	Oxamyl		149	0.02
2010	90	Hexazinone	5	8227	0.86
	156	Tebuthiuron		2130	0.22
	41	Clomazone	4	19680	2.05
	94	Imidacloprid		3781	0.39
	170	Triclopyr		2640	0.28
	144	Propoxur		2394	0.25
	15	Atrazine		1450	0.15
	162	Thiamethoxam		950	0.10
	105	Metalaxyl		904	0.09
	92	Imazapic		378	0.04
	126	Oxamyl		155	0.02
	22	Bentazone		96	0.01
2011	90	Hexazinone	5	4560	0.48
	156	Tebuthiuron		1550	0.16
	41	Clomazone	4	11933	1.27
	170	Triclopyr		6163	0.65
	94	Imidacloprid		3553	0.38
	144	Propoxur		2376	0.25
	162	Thiamethoxam		1917	0.20
	15	Atrazine		1500	0.16
	92	Imazapic		1092	0.12
	13	Amicarbazone		700	0.07
	22	Bentazone		624	0.07
	105	Metalaxyl		550	0.06

Annex 5: Imported formulated products containing active ingredients of primary concern

Human health

CompoundName	Abamectin

Sum of Volume_ai_kg	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Agrometic 1.8% EC	23	40	16	41	45	79	82	45	72	444
Moz Abamec Plus 18% EC								144	43	187
Volcano Agromectin 1.8% EC		18								18
Grand Total	**23**	**58**	**16**	**41**	**45**	**79**	**82**	**189**	**115**	**649**

CompoundName	Aldicarb

Sum of Volume_ai_kg	2003	2004	2005	Grand Total
Aldicarb 15% GR	570			570
Temik 15% GR	480	90		570
Volcano Aldicarb 15% GR	360	84	1710	2154
Grand Total	**1410**	**174**	**1710**	**3294**

CompoundName	Aluminium phosphide

Sum of Volume_ai_kg	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Aluminium Phosphide 57% FT		1262									1262
Falfume 57% FT			4560		3421	5016			7866		20863
Fumaphos 56% FT		3929	194	212	71	24					4428
Moz Aluminium Phosphide 56% FT										700	700
Phosgard 56% FT	847	1129	847	118	118	118	1164	259	294	823	5715
Quickphos 56% FD			1613			335					1948
Volcano Alluminium Phosphide 57% FT			570	1890	2457	3432		3711	8846	6823	27728
Grand Total	**847**	**6319**	**7783**	**2219**	**6066**	**8925**	**1164**	**3969**	**17006**	**8346**	**62645**

CompoundName	Fenamiphos

Sum of Volume_ai_kg	2002	2003	2005	2006	2007	Grand Total
Nemacur 10% GR		50				50
Nemacur 40% EC	200	300				500
Volamiphos 40% EC		300	800	410	600	2110
Grand Total	**200**	**650**	**800**	**410**	**600**	**2660**

CompoundName	Methomyl

Sum of Volume_ai_kg	2009	Grand Total
Kuik	900	900
Grand Total	**900**	**900**

CompoundName	Mevinphos

Sum of Volume_ai_kg	2003	Grand Total
Universal Mevinfos 15% EC	150	150
Grand Total	**150**	**150**

CompoundName	Monocrotophos

Sum of Volume_ai_kg	2003	2004	2007	Grand Total
Phoskill 40% SC		200	480	680
Universal Monocrotofos 40% SL	200			200
Grand Total	**200**	**200**	**480**	**880**

CompoundName	Oxamyl

Sum of Volume_ai_kg	2004	2005	2007	2008	2009	2010	2011	Grand Total
Villa Platoon 31% SL	78							78
Vydate 31% SL		50	37	93	149	155	93	577
Grand Total	**78**	**50**	**37**	**93**	**149**	**155**	**93**	**654**

CompoundName	Terbufos

Sum of Volume_ai_kg	2008	2009	Grand Total
Bongo		6750	6750
Rotam Terbufos 15% GR	4650		4650
Grand Total	**4650**	**6750**	**11400**

CompoundName	Diuron

Sum of Volume_ai_kg	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Acticide EPW							2			2
Diuron 80% SC	7200	1600			2592	4800				16192
Rocima 363 N							1	1		2
Volcano Diuron 800 SC	13200	43072	40976	40312	20480	28768	48896	37888	43312	316904
Grand Total	**20400**	**44672**	**40976**	**40312**	**23072**	**33568**	**48899**	**37889**	**43312**	**333100**

CompoundName	Mancozeb

Sum of Volume_ai_kg	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Dithan M 45 800 WP		800	4000	1600							6400
Dithane M 60 OS									390		390
Dithane NT 80% WP										800	800
Mancozeb 80% WP	1200	3440									4640
Metamin Fae Pm 72% WP										627	627
Milor								2624			2624
Milthane Super 80% WP									16000		16000
Policar MZ 80% WP										1408	1408
Ridomil Gold MZ 68 WG		1088	2304		346	576	1382			64	5760
Sunstar Super 72% WP									3200		3200
Unilax 72% WP			144			40					184
Unizeb 80% WP	800	3200	3600								7600
Uthane 80% WP			6400		4000	1600					12000
Volcano Crater MX 72% WP					2560	5120		2568	2432	3776	16456
Volcano Mancozeb 80% WP		6720	28400	18480	16760	23600	14400	24811	31552	54400	219123
Grand Total	**2000**	**15248**	**44848**	**20080**	**23666**	**30936**	**15782**	**30003**	**53574**	**61075**	**297212**

Environment

CompoundName	Lambda-cyhalothrin

Sum of Volume_ai_kg	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Cyclon 10 EC						2				2
Demand 2.5 CS		15								15
Duduthrin 5% EC								250		250
Fortis K 5% EC		1538	1641	3403	888	4949	2138	1503	1750	17808
Fortis Ultra 4.75% EC	375									375
Fortis Xtra 8.8% EC	2	1500	2069							3571
Icon 10 CS						45				45
Icon 10% WP	317	2334	6070	67	98	50			133	9069
Icon 2,5% EC	63	12	38	24	60	72				268
Iconet 2.5% CS	33	427	68	6						535
Karate 5% CS			18	651	33					702
Karate 5% EC	1368	2079	720				18			4185
Karate Zeon 5% CS						17			29	45
Lambda cyhalothrin 5% EC		88	53		1505					1645
Moz Lambda-Cyhalothrin 5% EC									6	6
Revival 10% WP							12033	21430		33463
Revival 25% EC						750	1595		750	3095
Zakaka Pro 64,8% EC			260	1166	1680	2160	1020	2021	3144	11451
Zakanaka Top 10% EC			510	3235	1673	1590	1634	3839	3630	16110
Zakanaka K 6% EC			300	3146	2280	3630	1966	1567	3318	16207
Zakanaka Topro 68,8% EC			630							630
Grand Total	**2158**	**7992**	**12377**	**11698**	**8216**	**13263**	**20403**	**30610**	**12760**	**119476**

CompoundName	Acetochlor

Sum of Volume_ai_kg	2003	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Acetochlor 90% EC	2700					3105				5805
Bullet 70% SC		126	75		126	126				453
Villa Acetochlor 90% EC			13320	3204						16524
Volcano Acetochlor 90% EC	11952	33642	45666	38250	30465	69008	66996	80856	57456	434291
Grand Total	**14652**	**33768**	**59061**	**41454**	**30591**	**72239**	**66996**	**80856**	**57456**	**457073**

CompoundName	Imidacloprid

Sum of Volume_ai_kg	2002	2004	2005	2006	2007	2008	2009	2010	2011	Grand Total
Bandit 35% SC					316	4756	3290	1629	1925	11916
Bandit 70% WG								2013		2013
Confidor 20% SL	129		162		104	140				535
Courage 60% FS			936							936
Courage 70% WS				12187	11900	9660	2013			35760
Gaucho 70% WS	140		1							141
Imidabiogel 2,15% PC					2		161	62	86	312
Imidacel 20% SL								77	300	377
Imidagold 20% SL					160	40	10			210
Maxforce Quantum RB									0	0
Midaclordan									500	500
Monceren GT 390 FS			140							140
Moz Imidacloprid 35% SC									42	42
Premise 35% SC							1			1
Protect 20% SL		332	730	180	400	202	480		700	3024
Quick Bait Spray Fly Bait									0	0
Seed Plus 30% WS					1	5				6
Thunder 145 O-TEQ			192		40					232
Grand Total	**269**	**332**	**2161**	**12367**	**12924**	**14802**	**5955**	**3781**	**3553**	**56144**

CompoundName	Methyl bromide

Sum of Volume_ai_kg	2003	2004	2005	Grand Total
Volcano Methyl Bromide 100 %GA	10290	12740	10290	33320
Grand Total	**10290**	**12740**	**10290**	**33320**

CompoundName	Tebuthiuron

Sum of Volume_ai_kg	2003	2005	2006	2007	2008	2009	2010	2011	Grand Total
Tebuthiuron 50% SC	2200				1400				3600
Volcano Bundu 50% SC		110			35	215			360
Volcano Tebuthiuron 500 SC	640	2840	5450	5590	2500	10640	2130	1550	31340
Grand Total	**2840**	**2950**	**5450**	**5590**	**3935**	**10855**	**2130**	**1550**	**35300**

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Alterra Wageningen UR is the research institute for our green living environment. We offer a combination of practical and scientific research in a multitude of disciplines related to the green world around us and the sustainable use of our living environment, such as flora and fauna, soil, water, the environment, geo-information and remote sensing, landscape and spatial planning, man and society.

The mission of Wageningen UR (University & Research centre) is 'To explore the potential of nature to improve the quality of life'. Within Wageningen UR, nine specialised research institutes of the DLO Foundation have joined forces with Wageningen University to help answer the most important questions in the domain of healthy food and living environment. With approximately 30 locations, 6,000 members of staff and 9,000 students, Wageningen UR is one of the leading organisations in its domain worldwide. The integral approach to problems and the cooperation between the various disciplines are at the heart of the unique Wageningen Approach.

PARAQUAT (057)

First draft prepared by Dr. Yukiko Yamada, National Food Research Institute, Tsukuba, Japan

EXPLANATION

Paraquat, a non-selective contact herbicide, was first evaluated in 1970 for toxicology and residues. Subsequently, it was reviewed for toxicology in 1972, 1976, 1982, 1985 and 1986, and for residues in 1972, 1976, 1978 and 1981. The 2003 JMPRMeeting reviewed paraquat toxicologically under the Periodic Review Programme and the current ADI of 0-0.005 mg paraquat cation/kg bw and acute RfD of 0.006 mg paraquat cation/kg bw were recommended. by the 2003 JMPR. The residue evaluation was postponed to the present Meeting. Currently there are 22 Codex MRLs for plant commodities, their derived products, and animal commodities.

The 32nd Session of the CCPR identified paraquat as a priority compound for Periodic Re-evaluation by the 2002 JMPR but residue evaluation was postponed to the present Meeting.

Paraquat is normally available in the form of the dichloride or bis(methyl sulfate) salt. The Meeting received data on metabolism, environmental fate, analytical methods, storage stability, supervised field trials and processing and information on use pattern.

IDENTITY

ISO common name: paraquat

Chemical name
IUPAC: 1,1′-dimethyl-4,4′-bipyridinium
CAS: 1,1′-dimethyl-4,4′-bipyridinium

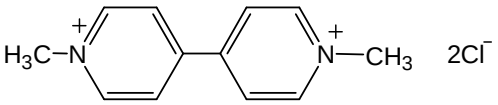
CAS Registry No.: 1910-42-5 (paraquat dichloride)
4685-14-7 (paraquat)

CIPAC No.: 56

The properties listed below refer to the dichloride

Synonyms and trade names: N,N'-dimethyl-4,4'-bi-pyridinium chloride, Gramoxone, Gramoxon, PP148, etc.

Structural formula:



Molecular formula: $C_{12}H_{14}N_2Cl_2$

Molecular weight: 257.2
(Molecular weight of paraquat ion is 186.3)

Physical and chemical properties

Pure active ingredient (Husband, 2001)

Purity:	99.5%
Appearance:	Off-white hygroscopic solid without characteristic odour
Vapour pressure:	<< $1x10^{-5}$ Pa at 25°C
Melting point:	No melting below 400°C; decomposition at around 340°C (613°K)
Boiling point:	Boiling point of pure paraquat dichloride not measurable; decomposition at ~340°C (613°K)
Relative density:	1.55 at 25°C
Surface tension:	73.4 mN/m at 20°C (at concentration of 0.02 M)
Henry's law constant:	$4x10^{-9}$ Pa m^3/mol
Octanol-water partition coefficient:	Log P_{ow} -4.5 at 25°C
Solubility at 20ºC:	Water: 618 g/l at pH 5.2 620 g/l at pH 7.2 620 g/l at pH 9.2 Methanol: 143 g/l Acetone: <0.1 g/l Hexane: <0.1 g/l Dichloromethane: <0.1 g/l Toluene: <0.1 g/l Ethyl acetate: <0.01 g/l
pH at 20°C	6.4
Stability:	≥14 days at 54°C
Hydrolysis:	No hydrolysis was observed at pH 5, 7 or 9 (91 mg/l; 25 or 40°C for 30 days)
Photolysis:	In aqueous solution, photochemically decomposed by UV radiation

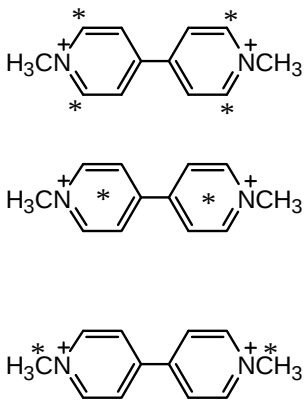
Technical material (Wollerton. 1987)

Purity:	Minimum 362 g/l (tested material: 529 g/l)
Appearance:	Dark red-brown clear liquid
Odour:	Earthy odour
Density:	1.13 g/cm^3 at 25°C

pH:	3.95 at approximately 20 °C
Flash point:	> 90 °C
Surface tension:	58.6 mN/m at 20 °C
Storage stability:	≥2 years at 25 °C in polythene
Formulations:	SL (in various concentrations alone or in combination with diquat)

METABOLISM AND ENVIRONMENTAL FATE

For studies of metabolism in animals and plants, [^{14}C]paraquat was labelled as shown (Figure 1). The structures of metabolites identified in these studies are shown in Figure 2.



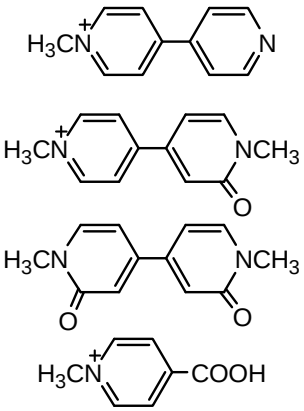
[2,2′,6,6′-^{14}C]paraquat

[U-^{14}C-dipyridyl]paraquat

[1,1′-^{14}C-dimethyl]paraquat

(*position of ^{14}C label)

Figure 1. Radiolabelled paraquat used in metabolism studies.



Monoquat

Paraquat monopyridone (MP)

Paraquat dipyridone (DP)

4-carboxy-1-methylpyridinium ion
(*N*-methyl isonicotinic acid (MINA))

Figure 2. Structures of metabolites identified in metabolism studies.

Animal metabolism

The Meeting received information on the fate of orally-dosed paraquat in rats, sheep, pigs, a lactating cow and goat, and laying hens.

Rats. The excretion balance of paraquat in male and female Alpk:ApfSD rats which were given a single dose (at either 1 mg/kg bw or 50 mg/kg bw of [1,1′-^{14}C-dimethyl]paraquat dichloride) or repeated doses (1 mg/kg bw of radiolabelled paraquat dichloride following 14 daily doses of 1 mg/kg unlabelled compound) (Lythgoe & Howard, 1995 a-c, reported in Macpharson, 1995) was evaluated by the WHO Core Assessment Group of the 2003 JMPR. It concluded that paraquat was not well absorbed when administered orally. After oral administration of radiolabelled paraquat to rats, more than half the dose (60-70%) appeared in the faeces and a small proportion (10-20%) in the urine. Excretion was rapid: about 90% within 72 h.

The biotransformation of paraquat was studied by Macpherson (1995) who analysed urine and tissue samples of rats administered the same doses of radiolabelled paraquat as above by TLC and HPLC. This was also reviewed by the WHO Core Assessment Group of the 2003 JMPR together with other rat metabolism and toxicity studies. It was concluded that paraquat is largely eliminated unchanged - approximately 90-95% of radiolabelled paraquat in the urine was excreted as the parent. In some studies no metabolites were identified after oral administration of paraquat, while in others a small degree of metabolism probably occurring in the gut as a result of microbial metabolism was observed. Paraquat was not found in the bile.

Sheep. In a study by Hemmingway *et al.* (1972) on two sheep [1,1′-^{14}C-dimethyl]paraquat dichloride was administered via a rumen fistula to one sheep weighing 73.5 kg (7.14 mg of radiolabelled+1.7035 g unlabelled paraquat in 30 ml of water) and to another weighing 60.5 kg via subcutaneous injection (0.87 mg of radiolabelled+54.5 mg unlabelled paraquat in 4 ml of water). Urine and faeces from these sheep were collected for 10 days. For spectrophotometric determination of paraquat, 100 g of faeces were boiled with 500 ml of 2N H_2SO_2 for three hours, the digest was filtered, and the filtrate diluted with an equal volume of water. An aliquot of urine or an aliquot of faeces sample processed as above was percolated separately through a column of cation-exchange resin. The column was washed with 2.5% ammonium chloride solution and the paraquat eluted with saturated ammonium chloride solution. A portion of the column effluent was treated with sodium dithionite in an alkali solution, which reduces paraquat to a free radical whose absorption was measured photometrically at 396 nm with background correction.

It appeared that via rumen fistula, all administered radioactivity was recovered within 10 days in urine and faeces: approximately 4% from the urine and the remainder from the faeces (Table 1). Most of the radioactivity was excreted in the faeces on days 2-5. These results indicate that residues of paraquat do not remain or accumulate in the tissues of sheep when the dose is administered orally.

Table 1. Residues in the urine and faeces of sheep given radiolabelled paraquat via rumen fistula (Hemmingway *et al.*, 1972).

Day	% of administered radioactivity		% of paraquat in excreted radioactivity*		% of radioactivity on paper chromatogram (faeces)	
	Urine	Faeces	Urine	Faeces	Paraquat	Other bands**
1	1.66	0.8	74 (83)	81 (93)	-	-
2	1.13	22	87 (95)	89 (90)	99	1
3	0.68	22	78 (88)	85 (101)	99	1
4	0.20	27	77 (80)	86 (89)	99	1
5	0.12	15	72 (80)	94 (103)	98	2
6	0.057	7.5	69 (78)	79 (97)	97	3
7	0.034	4.3	80 (82)	84 (88)	-	-
8	0.029	1.3	76 (87)	59 (87)	-	-
9	0.020	0.53	66 (79)	55 (77)	-	-

Day	% of administered radioactivity		% of paraquat in excreted radioactivity*		% of radioactivity on paper chromatogram (faeces)	
	Urine	Faeces	Urine	Faeces	Paraquat	Other bands**
10	0.016	0.23	78 (95)	47 (70)	-	-
Total	3.9	100.7	-	-	-	-

* Percentage of paraquat in the saturated ammonium chloride eluate from a cation-exchange column in parentheses.
** MP + MINA + DP + solvent front area + origin area (solvent system: iso-propanol:ethanol:NH_4Cl 3:3:2)

The urine and faeces samples, after fractionation on a cation-exchange column, were analysed by paper chromatography (solvent system: iso-propanol:ethanol:NH_4Cl 3:3:2; and n-butanol:acetic acid:water 4:1:2). The chromatograms showed that most of the radioactivity in these samples was unchanged paraquat, and about 2-3% MP. A trace (<1%) can be accounted for as MINA and DP in the iso-propanol:ethanol:NH_4Cl solvent system, and monoquat in the n-butanol:acetic acid:water solvent system. The results of paper chromatography (solvent system of iso-propanol:ethanol:NH_4Cl 3:3:2) of the faecal samples are also shown in Table 1.

Subcutaneously administered paraquat was also excreted very rapidly. Over 80% of the administered radioactivity was excreted in the urine; 69% one day after the treatment. Unchanged paraquat accounted for most of the radioactivity, MP for 2-3%, and monoquat was a trace metabolite. This pattern is virtually identical to that seen in urine after administration via the rumen fistula.

Pigs. In a trial in 1976 Leahey *et al.* dosed one pig weighing about 40 kg twice daily with [1,1′-^{14}C-dimethyl]paraquat ion in the diet at a rate of about 100 mg a day, equivalent to 50 mg/kg in the diet for 7 days. Another pig was used as a control. After the first dose, blood was sampled at hourly intervals and the radioactivity measured to determine when peak levels were reached. On subsequent days, a blood sample was taken after the morning dose after an interval corresponding to the time taken to reach the maximum blood level. The faeces and urine were collected from the day before the first administration and the pig was slaughtered two hours after the morning dose on the seventh day and, after bleeding, samples of liver, kidney, muscle, fat, heart, blood, lung and brain were taken. The content of paraquat in the tissues was determined by reverse-isotope dilution.

The radioactivity levels in blood samples increased after the morning dose on the first day, reaching a maximum within two hours of dosing, and then decreased very slowly. The radioactivity in blood did not increase significantly after the second day.

At the time of slaughter 69% of the administered radioactivity had been excreted in the faeces and 3.4% in the urine, and 13.4% was found in the stomach contents and viscera.

The distribution of radioactivity in the tissues All the radioactivity found in all tissues except the liver could be accounted for as paraquat. In the liver about 70% was determined as paraquat, 7% as the monoquat ion and a trace (c.0.6%) of MP ion.

Table 2. Distribution of radioactivity in the tissues of a pig dosed with [1,1′-^{14}C-dimethyl]paraquat for 7 days (Leahey *et al.*, 1976).

Sample	Radioactivity as paraquat ion equivalents mg/kg	% of radioactivity as paraquat
Hindquarter muscle	0.03	94
Forequarter muscle	0.06	106
Subcutaneous fat	0.02	115
Peritoneal fat	0.06	102

Sample	Radioactivity as paraquat ion equivalents mg/kg	% of radioactivity as paraquat
Liver	0.20	73
Kidney	0.46	109
Heart	0.12	104
Lung	0.12	105
Brain	0.02	108
Blood	0.07	104

Spinks *et al.* in 1976 conducted a similar study except that [2,2′,6,6′-^{14}C]paraquat was used instead of [1,1′-^{14}C-dimethyl]paraquat ion. At slaughter, 72.5% of the administered radioactivity had been excreted in the faeces and 2.8% in the urine.

The distribution of radioactivity in the tissues at the time of slaughter is shown in Table 3. There was no significant metabolism of paraquat in most of the tissues. In the liver, approximately 70% of the radioactivity was accounted for as paraquat with 4% as monoquat.

Table 3. Distribution of radioactivity in tissues of pig dosed with [2,2′,6,6′-^{14}C]paraquat ion for 7 days (Spinks *et al.*, 1976).

Sample	Radioactivity as paraquat ion equivalents mg/kg	% of radioactivity as paraquat
Hindquarter muscle	0.05	93
Forequarter muscle	0.05	95
Subcutaneous fat	0.01	105
Peritoneal fat	0.01	106
Liver	0.10	70
Kidney	0.38	101
Heart	0.08	81
Lung	0.10	94
Brain	0.03	62
Blood	0.06	71

Lactating cow. In a study by Leahey *et al.* (1972), [1,1′-^{14}C-dimethyl]paraquat dichloride was administered using a balling gun to a Friesian cow (475 kg) in a single dose equivalent to approximately 8 mg/kg paraquat ion. The faeces and urine were thereafter collected for nine days, and the milk collected each day in the morning and afternoon (each day of the experiment started at afternoon milking). Faeces and urine samples were processed as in the study on sheep above for spectrophotometric analysis. For the milk samples, five g of cation-exchange resin were added to two l of day-2 pm milk in a polythene bottle which was placed on mechanical rollers for 2.75 hours. After removal of the milk, the resin was transferred to a burette with glass wool above the stopcock. The resin

was washed with 150 ml of 2.5% aqueous ammonium chloride and then eluted with 50 ml of saturated ammonium chloride. The first 25 ml eluate was analysed spectrophotometrically in the same manner as used for the urine samples. This eluate contained 70% of the radioactivity adsorbed onto the resin from the milk.

Virtually all the administered radioactivity was excreted within nine days: a total of 95.6% was excreted in the faeces (Table 4). In the first three days a total of 89% was excreted. A small amount (0.7%) was excreted in the urine and 0.56% (80% of that excreted in the urine) was excreted in the first two days. Only 0.0032% of the administered radioactivity was recovered from the milk.

Table 4. Excretion of administered paraquat in the faeces, urine and milk of a cow dosed orally with radiolabelled paraquat (Leahey, 1972).

Day	% of administered radioactivity		
	Faeces	Urine	Milk
1	25.9	0.31	0.0009
2	49.5	0.26	0.001
3	14.0	0.08	0.0005
4	3.3	0.03	0.0003
5	2.1	0.01	0.0002
6	0.6	0.005	0.0001
7	0.14	0.004	0.0001
8	0.03	0.006	0.00007
9	<0.01	0.002	0.00005
Total	95.6	0.7	0.0032

Paper chromatography (solvent system iso-propanol:ethanol:NH_4Cl, 3:3:2) of faecal extracts showed that paraquat was the main radioactive compound in the faeces. It accounted for 97-99% of the radioactivity recovered in day 1-4 samples (Table 5) and was the only radioactive component detected in the faeces from days 5 and 6.

Table 5. Analysis of faecal extracts by paper chromatography (Leahey, 1972).

Day	% of radioactivity in paraquat band	% radioactivity in remainder of chromatogram
1	99	1
2	98	2
3	97	3
4	97	3

Paraquat accounted for 90, 70 and 62% of the radioactivity in the urine from days 1, 3 and 5, respectively. The remaining activity was accounted for as MP and monoquat.

The traces of radioactivity in the milk (a maximum of 0.005 mg paraquat ion equivalent/l in day-2 a.m. milk and decreasing thereafter) were mainly accounted for as paraquat and MP, and as naturally incorporated radioactivity. The latter appears to be radioactive lactose in the milk (Table 6). The residue of any single compound was not above 0.002 mg/kg.

Table 6. Radioactive residues in milk (Leahey, 1972).

Day	% of total radioactivity after paper chromatography			
	Paraquat	Monoquat[1]	MP	Lactose[2]
1	15	15	3	27.5
	(0.5 µg/l)	(0.9 µg/l)	(0.1 µg/l)	
2 a.m.	17.5	17.5	18	27.5
	(0.6 µg/l)	(1 µg/l)	(0.6 µg/l)	
3 a.m.	9	25	10	28
	(0.2 µg/kg)	(0.8 µg/kg)	(0.2 µg/kg)	

[1] Since monoquat has lost one of the two radioactive carbons of diquat, the residue in µg/l will be double that for paraquat, when the two compounds are present at the same % of the total activity.

[2] These results based on milk containing 4% lactose, a normal lactose content.

Lactating goat. In a metabolism study (Hendley, 1976a), a lactating goat was dosed with [2,2′,6,6′-^{14}C]paraquat dichloride twice daily at each milking for 7 days at a total daily rate of 206.6 mg in the normal diet, approximately equivalent to 100 ppm in the diet. A second lactating goat was used as a control. Both goats were killed four hours after the final dose and, after bleeding, samples of liver, kidney, hindquarter and forequarter muscle, peritoneal and subcutaneous fat, heart, lung, brain and blood were taken. The faeces and urine were collected from two days before the first dose and throughout the study, and milk too was collected in the morning and afternoon two days before dosing until the animals were slaughtered.

At slaughter 50.3 and 2.4 of the administered radioactivity had been excreted in the faeces and urine and 33.2% was in the stomach contents.

The total radioactivity as paraquat ion equivalents in the collected milk increased over the experimental period reaching the highest level of 0.0092 mg/kg (equivalent to 0.003% of the daily dose) four hours before slaughter (Table 7). Analysis of milk by reverse-isotope dilution indicated that 75.7% of this radioactivity was attributable to paraquat. 15.8% of the radioactivity was not adsorbed onto the cation exchange resin.

Table 7. Total radioactivity in milk expressed in paraquat ion equivalents (Hendley, 1976a).

Day/time	Total radioactivity mg-paraquat ion equivalents/kg
1 evening	0
1 morning	<0.001
2 evening	0.0010
2 morning	0.0013
3 evening	0.0018
3 morning	0.0026
4 evening	0.0030
4 morning	0.0038
5 evening	0.0048
5 morning	0.0051
6 evening	0.0064
6 morning	0.0064
7 evening	0.0083
7 morning	0.0092

[1] an experimental day starts at 10 am and ends at 10 am. As a result evening milk precedes morning milk

The distribution of radioactivity in goat tissues at the time of slaughter is shown in Table 8.

Table 8. Distribution of radioactivity in the tissues of goat given [2,2′,6,6′-^{14}C]paraquat ion (Hendley, 1976a).

Sample	Radioactivity as paraquat ion equivalents mg/kg	% of radioactivity as		
		Paraquat	MP	Monoquat
Hindquarter muscle	0.12	100	-	-
Forequarter muscle	0.08	90	-	-
Subcutaneous fat	0.02	121	-	-
Peritoneal fat	0.03	49	-	6.5
Liver	0.56	48	3.2	3.4
Kidney	0.74	95	-	-

Sample	Radioactivity as paraquat ion equivalents mg/kg	% of radioactivity as		
		Paraquat	MP	Monoquat
Heart	0.16	118	-	-
Brain	0.13	106	-	-
Blood	0.06	82	-	-

NB: no reliable result could be obtained for lung, possibly due to vomiting at the time of slaughter and regurgitated diet containing radiolabelled paraquat entering the lungs.

In all tissues except liver and peritoneal fat, there appears to be no significant metabolism of paraquat. In the liver and peritoneal fat, approximately half of the radioactivity was attributable to paraquat with >5% identified as MP ion and approximately 5% as monoquat.

Laying hens. Three Warren 15-month old laying hens were dosed daily with 4.52 mg of [2,2′,6,6′-^{14}C]paraquat ion in gelatin capsules, equivalent to 30 ppm in the normal diet (Hendley *et al.*, 1976b) for ten days, and killed four hours after the final dose. Eggs and excreta were collected throughout the dosing period and samples of meat, fat, kidney and liver were taken after the hens were killed.

By the time the hens were killed 99% of the administered radioactivity had been excreted in the faeces; a minimum of 96.6% as unchanged paraquat.

The distribution of radioactivity in the hen tissues is shown in Table 9.

Table 9. Distribution of radioactivity in hens given [2,2′,6,6′-^{14}C]paraquat (Hendley *et al.*, 1976b).

Sample	Radioactivity as paraquat ion equivalents* mg/kg	% of radioactivity identified as	
		Paraquat	Monoquat
Breast muscle	0.008		
Leg muscle	0.040	98	
Kidney	0.113	86	4.1
Liver	0.072	80	3.6
Lung	0.029	86	
Heart	0.030	87	
Gizzard	0.079	98	
Subcutaneous fat	0.004		
Abdominal Fat	0.004	83**	

* Average of three birds, except for gizzard average of two birds.

** One bird.

In eggs the radioactivity in the albumen was never above 0.0014 mg/kg paraquat ion equivalents and in the yolks was <0.001 mg/kg paraquat ion equivalents on day 1, gradually increasing to 0.18 mg/kg (one bird) on day 8, the last day eggs were collected. All of the radioactivity in the yolks was identified as paraquat.

Proposed metabolic pathways in animals.

Studies demonstrated that administered paraquat is generally excreted, mostly in the faeces virtually unchanged and to a much lesser extent in urine. Excretion was particularly rapid in hens, with less than 0.05 mg/kg of paraquat found in the muscle, milk and eggs even at exaggerated dose rates. These findings indicate that only little paraquat was absorbed from the gastro-intestinal tract and no significant bioaccumulation of paraquat was expected to occur.

The metabolism of paraquat in these animals was very similar. No more than 50% of the absorbed paraquat was metabolized to monoquat and MP and to an even lesser extent to MINA.

Proposed metabolic pathways of paraquat in animals are shown in Figure 3.

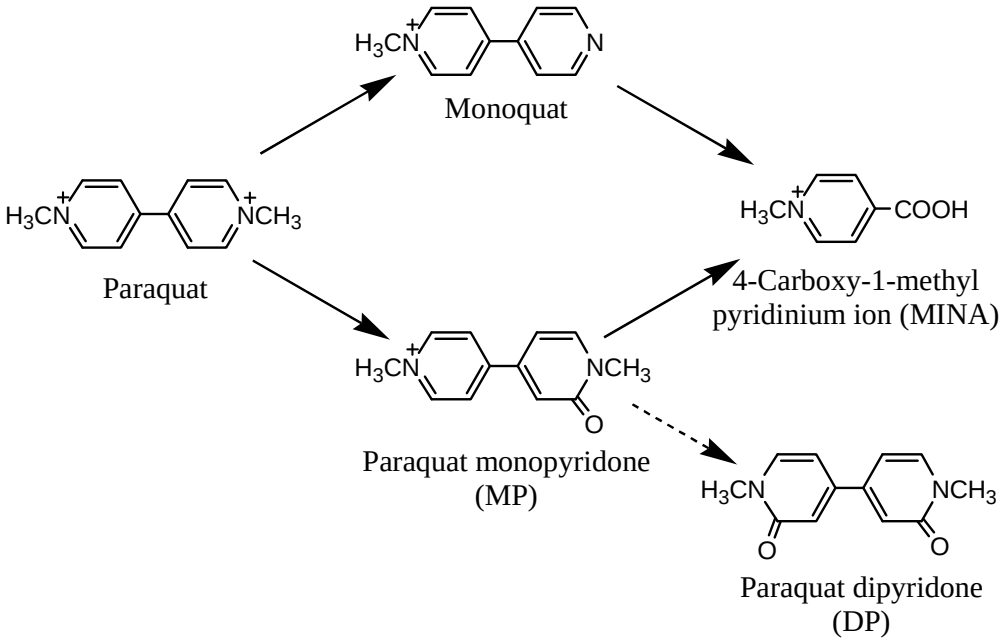


Figure 3. Proposed metabolic pathways of paraquat in animals.

Plant metabolism

The Meeting received information on the fate of paraquat after pre-emergence directed uses on lettuce and carrots and after desiccation uses on potatoes and soya beans.

Pre-emergence directed uses on lettuce and carrot. In pre-sowing, pre-planting, pre-emergence and post-emergence directed spray uses, paraquat is present in soil as residues to which crops are exposed but no direct contact of crops with paraquat will occur.

In a UK study by Grout (1994a) Lobjoits lettuce and Early Nantes carrots were sown in pots (two pots for each crop) containing sandy-loam soil and the pots sprayed evenly with [U-^{14}C-bipyridyl]paraquat immediately after sowing at rates equivalent to 14.3 kg ai/ha for lettuce and 14.7 kg ai/ha for carrots (about 13 times than the highest current single application rates). The pots were kept in a greenhouse and plants harvested 65 days (lettuce) and 96 days (carrots) after treatment. A control carrot sample was harvested 95 days after sowing.

The radioactivity in the lettuce leaves and carrots was very low (0.0034 and 0.0048 mg/kg paraquat ion equivalent). This result demonstrates that there is no significant translocation of residues of paraquat from treated soil to lettuce leaves or carrot roots.

Post-emergence uses on potato and soya beans. Paraquat can be used as a crop desiccant and harvest aid. In these uses, paraquat contacts crops directly.

In a greenhouse trial by Grout (1994b) in the UK potatoes and soya beans were grown in pots. To maximize residues the foliage was treated with [^{14}C]paraquat at rates equivalent to 8.7 or 8.8 kg ai/ha for potatoes, and 8.2 kg ai/ha soya plants. These rates were 14-15 times the highest current use for desiccation on potato plants and 16 times that on soya bean plants. Plants were harvested 4 days after treatment, except that a control soya plant which was harvested 3 days after the day of treatment. The plants were separated into foliage and tubers (potato) or pods, foliage and root (soya beans) with soil carefully removed. The potato tubers, soya beans and soya foliage were analysed for radioactivity and metabolites (TLC).

The total radioactive residue (TRR) in the potato tubers, soya beans and foliage was determined by combustion analysis. For characterization of radioactive residues, potato tubers, soya beans and soya foliage were extracted with a series of solvents (shown below) and the radioactivity of the obtained extracts was measured by liquid scintillation counting and of the remaining debris by combustion.

Potato tuber:	Acetonitrile → 2M HCl → 6M HCl (refluxing for 4 h)
Soya beans:	Hexane → Dichloromethane → Water (Extraction of the remaining debris: 2M HCl → 6M HCl (refluxing for 4 h))
Soya foliage:	Dichloromethane → 2M HCl → 6M HCl (refluxing for 4 h)

The TRR in the samples was calculated as a sum of the radioactivity in the extracts and in the debris. Extracts were analysed by TLC (solvent system I, acetonitrile:water:acetic acid, 5:4:1; and solvent system II, 2M HCl:iso-propanol, 19:1) and the results confirmed with reverse-phase HPLC (column, S5 ODS2, 25 cm x 4.6 mm i.d.; flow rate, 2.0 mgl/min; detection wavelength, 290 nm; mobile phase, water:methanol 3:1 plus 12.7 ml of orthophosphoric acid, 10.3 ml of diethylamine and 2.29 g of sodium octanesulphonate acid per l). The 2M HCl extract and of soya foliage sample was further analysed by HPLC with two different solvent systems (system III, water:methanol 19:1 plus 12.7 ml of orthophosphoric acid, 10.3 ml of diethylamine and 2.29 g of sodium octanesulphonate acid per l, followed by water:methanol 3:1 plus 12.7 ml of orthophosphoric acid, 10.3 ml of diethylamine and 2.29 g of sodium octanesulphonate acid per l; and sytem IV, deionized water followed by 7.4% trifluoroacetic acid in deionized water) for confirmation of the presence of monoquat and MINA.

The average TRRs expressed as paraquat ion equivalents in soya foliage and beans was 638 and 0.747 mg/kg and in potato tubers 0.082 mg/kg. In the potato tubers, soya beans and soya foliage, 90.2%, 88.9% and 93.8% of the TRR (sum of radioactivity in extracts and debris combined) of each sample respectively was identified as paraquat. The remainder consisted of 2 or 3 fractions, none of which exceeded 10% (Table 8). In soya foliage extracts, a small proportion of MINA (0.3% of the TRR of extracts and debris combined), a known phododegradation product of paraquat, and monoquat (0.3 % of the TRR of extracts and debris combined) were found.

Table 10. TRR in potato and soya beans (Grout, 1994b).

Sample	TRR as paraquat ion equivalents, mg/kg		
	Potato tuber	Soya beans	Soya foliage
Plant parts from treated plants (2)	0.089 0.075[1]	0.841[1] 0.652	506 769[1]
Plant parts from control plant (1)	<0.0012	<0.0034	<0.0035
Extracts + debris	0.088	0.793	844

Sample	Fraction	% of TRR[2]	Residue as paraquat ion equivalent, mg/kg
Potato tuber	Identified as paraquat ion	90.2	0.079
	Aqueous fraction after reflux with 6M HCL	7.5	0.007
	Unextracted	1.0	<0.001
	TLC remainder[3]	2.4	0.002
	Loss on work-up	(-1.1)	(-0.001)
	Total	100.0	-
Soya beans	Identified as paraquat ion	88.9	0.705
	Hexane extract	0.4	0.003
	Unextracted	0.9	0.007
	TLC remainder[3]	4.4	0.035
	Loss on work-up	5.4	0.043
	Total	100.0	-
Soya foliage	Identified as paraquat ion	93.8	792
	Identified as MINA	0.3	2.5
	Identified as monoquat	0.3	2.5
	Unextracted	1.0	8.4
	TLC remainder[4]	5.1	43.1
	Loss on work-up	(-0.5)	(-4.2)
	Total	100.0	-

[1] Sample used for extraction and TLC analysis.
[2] Extracts and debris combined.
[3] Consists of background noise between regions of interest from TLC.
[4] Consists of background noise, an unknown from TLC analysis (Unknown 1, 1.2% of TRR) and some streaking between regions of interest from TLC, plus low levels of activity between regions of interest from HPLC.

Proposed metabolic pathway in plants

Pre-emergence and post-emergence directed use of paraquat does not cause crops to have direct contact with paraquat. Since paraquat is well adsorbed by soil, its uptake by the plant is insignificant even at exaggerated application rates. When paraquat was applied as a desiccant to potato and soya beans at a rate >10 times the highest recommended application rate, with a 4 day PHI, the predominant component in potato tubers, soya beans and soya foliage was paraquat. In soya foliage, monoquat and MINA were also found. Although MINA is a known photodegradation product and it was not found in soya beans or potato tuber, a possibility of biotransformation cannot be excluded because the TRR in them were too low for reliable identification. Since the fate of paraquat in soya foliage seems to involve photodegradation, its fate is considered to be common among plants.

The proposed metabolic pathways of paraquat in plants are shown in Figure 4.

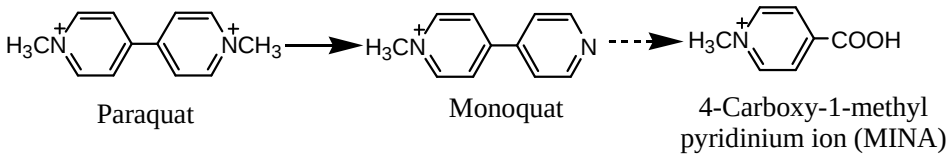


Figure 43. Proposed metabolic pathways of paraquat in plants.

Environmental fate in soil

The Meeting reviewed information on aerobic degradation and adsorption/desorption in soil as per the decision of the 2003 JMPR. Information on microbiological degradation of paraquat in soil was also reviewed in an attempt to estimate degradation pathways of paraquat in soil after its application.

When paraquat was applied to the slurries of four UK soils (10 g of loam, loamy sand, silty clay loam, and coarse sand in 200 ml of 0.01M calcium chloride in water) at two different rates that were regarded as above the adsorption capacity of the soil to give 0.01 mg/l in the equilibrium solution after a 16-hour equilibration on a reciprocal shaker, the calculated adsorption coefficients, Kd, ranged from 480 in the coarse sand to 50000 in the loam. With lower (normal) application rates Kd values were expected to be much higher but it was impossible to determine paraquat in the equilibrium solution (<0.0075 mg/l). No significant desorption was seen during the desorption step.

A field survey of 242 agricultural soils in Denmark, Germany, Greece, Italy, The Netherlands and the UK showed that paraquat is strongly adsorbed to all the soil types studied. The adsorption coefficients were calculated at rates much higher than normal application rates because the concentration in the equilibrium solution was below the limit of determination (0.01 mg/l) at normal application rates. The calculated Kd values ranged from 980 to 400000 and those adjusted for the organic carbon content in soil were 8400 – 40000000, although Kd is generally underestimated at higher application rates. Using the McCall scale (McCall *et al.*, 1980) for assessing mobility of chemicals in soil, paraquat was classified as “immobile” in all the soils studied and had no potential to be leached. The data showed that paraquat adsorption was predominantly related to clay content and the adsorption to clay was so strong that it masked any relationship between adsorption and soil organic matter content. Paraquat adsorption increased linearly as clay content increased with a high correlation coefficient of r^2=0.79 but paraquat adsorption showed no relationship to organic matter content. (Dyson *et al.*, 1994).

Aerobic degradation

[2,6-^{14}C]paraquat was applied to sandy loam soil in pots (3 cm h x 3.7 cm d) at a nominal rate of 1.05 kg/ha and incubated in darkness at 20 ± 2°C under aerobic conditions. At 0, 3, 7, 30, 61, 90 and 180 days after treatment, duplicate pots of soil was removed for extraction with methanol, followed by extraction with an aqueous solution of unlabelled paraquat and then with 6M HCL under reflux. The extracts were analysed by TLC and HPLC. Radioactivity recovered from soil extracts, extraction debris and volatile products were 92.5-107%. Less than 0.1% of the applied radioactivity was evolved as $^{14}CO_2$ over the 180 day incubation period. Paraquat accounted for >93% of the applied radiocarbon at the end of the incubation period and no degradation products were detected. This indicated a long half-life of paraquat in soil which could not be estimated. (Vickers *et al.*, 1989)

In the long-term field dissipation studies conducted on cropped plots located throughout the world, including Australia, Malaysia, The Netherlands, Thailand, the UK and the USA (Fryer *et al.*, 1975; Gowman *et al.*, 1980; Hance *et al.*, 1980; Wilkinson, 1980; Cole *et al.*, 1984; Hance *et al.*, 1984; Moore, 1989; Dyson & Chapman, 1995; Dyson *et al.*, 1995a; Dyson *et al.*, 1995b; Muller & Roy, 1997; Lane *et al.*, 2000; Lane & Ngim, 2000; Roberts *et al.*, 2002), no major effect of the location on the field dissipation rate was observed. Generally, paraquat residues declined to around 50% at the end of the studies, which was about 10 to 20 years. This implies that a DT_{50} is estimated to be in the rage of 10 to

20 years after applying single large treatments of paraquat to soil. However, a DT_{90} could not be estimated as time points after 90% degradation was not available.

Microbiological degradation in soil

Conventional laboratory studies could not provide useful information on the degradation route and rate of paraquat in soil because of its strong adsorption. Although paraquat is readily degraded by certain selected soil microorganisms when in a soil solution, its extremely strong adsorption to soil minerals and organic matter, accounting for its rapid biological deactivation, limits the rate at which degradation occurs. Alternative studies were therefore carried out to determine the route and rate of degradation of paraquat in soil.

The route of degradation has been elucidated from studies with paraquat in cultures of soil microorganisms, whilst the rate of degradation has been established from long-term field trials.

Baldwin found that the most effective organism for decomposing paraquat was a yeast, isolated from several soils and identified as ***Lipomyces starkeyi***. This yeast can utilize paraquat as a sole source of nitrogen. When incubated with [1,1′-^{14}C]paraquat or [2,2′,3,3′-^{14}C]paraquat, it decomposed 95% of 20 mg/kg paraquat in the culture in 2 weeks and 82-84% of the radioactivity was released as CO_2 during 4 weeks at 24°C. No intermediate degradation products were detected in the culture medium (Baldwin ***et al.***, 1966).

A large-scale incubation of ***Lipomyces starkeyi*** was carried out in 7 l of sucrose mineral salts medium with 100 mg/kg paraquat as the sole nitrogen source. After 4 weeks of incubation at 25 °C with continuous air agitation, the medium was acidified to pH 1 and heated to 100°C. The volume was then reduceds to 2 l and was extracted with ether. After two days crystals were formed in the ether extract, which were identified as oxalic acid after purification. When [1,1′-^{14}C]paraquat was added at the beginning of the incubation, oxalic acid formed after 12 days of incubation contained only 2% of the original radioactivity, but when [2,2′,3,3′-^{14}C]paraquat was added, the oxalic acid retained 25% of the original radioactivity. It was speculated that pyridine-ring carbons are liberated and then incorporated into the normal metabolic pathway. All the paraquat added to the medium was decomposed in 7 days and about 80% of the radioactivity was lost as $^{14}CO_2$ in 12 days (Baldwin, 1971).

[U-^{14}C-dipyridyl]paraquat was added at 10 or 100 mg/kg to incubation vessels containing either ***Lipomyces starkeyi*** cultures or cultures originating from two sandy loam soils taken from Frensham and Broadricks sites. This mixture was incubated at 20°C, in the absence of light and under aerobic conditions, for 20–36 days. Paraquat was extensively metabolized with the rapid production of $^{14}CO_2$. Typical mineralization to CO_2 was around 40, 50 and 55% for the ***Lipomyces*** culture, the Broadricks culture and the Frensham culture incubations respectively. TLC analysis of the incubation solutions showed almost identical radiolabelled metabolite profiles among the cultures. A major metabolite consisting >85% of the remaining radiochemical in the incubation solution, a minor metabolite (<5%) and a metabolite which was incorporated in the degrading microbial cultures (<10%) were characterized. The major metabolite was identified by HPLC, capillary electrophoresis and mass spectrometry as oxalic acid. No paraquat was identified in any of the incubation solutions where mineralization had taken place (Rickets, 1997).

An unidentified bacterium isolated from soil was incubated with [1,1′-14C]paraquat. The radioautography of the thin-layer chromatogram of the culture filtrate after 4 days incubation showed two new radioactive spots in addition to paraquat. These were tentatively identified as monoquat and MINA (Funderburk and Bozarth, 1967).

The degradation of MINA was studied by incubating the extract of Achromobacter D with 4-carboxy-1-methylpyridinium chloride which was labelled with ^{14}C at the *N*-methyl, carboxyl or pyridine ring (positions 2 & 3) moiety. The results showed that the extracts of Achromobacter D produced CO_2, methylamine, succinate and formate as metabolic end-products of MINA. The CO_2 was

demonstrated to originate from the carboxyl group and methylamine from the *N*-methyl group by the experiments using carboxy-labelled paraquat and *N*-methyl labelled paraquat respectively. The carbon skeletons of formate and succinate were shown to arise from the C-2 and C-3-C-6 atoms of the pyridine ring respectively by the experiment using pyridine-labelled paraquat. The latter results indicated the cleavage of pyridine between C-2 and C-3 (Wright and Cain, 1972).

In order to determine the degradation rate of paraquat in soil, [U-^{14}C-dipyridyl]paraquat was incubated at 10 mg/kg with pure cultures of Lipomyces and mixed cultures derived from two soils (Frensham loamy sand and 18 Acres sandy clay loam). The aqueous soil extracts from these were used for both the mixed and pure cultures to represent typical chemical conditions in soil pore water with respect to the supply of minerals. In these culture systems, the degradation of paraquat was rapid, with DT_{50} values between 0.02 and 1.3 days following a lag phase of about 2 days. Degradation of the parent compound was also accompanied by rapid mineralization to CO_2, reaching a maximum of 71.6% 7 days after treatment. Several minor polar metabolites were found although not identified. These results confirmed that paraquat is biodegradable (Kuet *et al.*, 2001).

Photolysis on a soil surface

The photolysis of [2,2′,6,6′-^{14}C]paraquat was studied in the UK. Radiolabelled paraquat was added to the surface of a very sandy soil. Paraquat was exposed to natural sunlight for periods up to 85 weeks. Some samples were mixed at regular intervals while others were not mixed. Dark controls were stored at -12°C and analysed simultaneously with exposed samples. The proportion of radioactivity identified as paraquat declined throughout the 85 weeks in samples; and at the end of the study it represented less than 89.5% and 86.6% of the total radioactivity found in the unmixed soil and the mixed soil respectively. Paraquat accounted for 95.0% of the total activity in the dark control sample after 85 weeks. TLC analysis of the 6M HCl extracts of both mixed and unmixed soils showed monoquat ion and MP ion. After 85 weeks of experiment, monoquat ion and MP ion were 1.4% and 1.3% respectively of the total radioactivity in the unmixed soil; and 2.4% and 1.2% respectively in the mixed soil. A third, uncharacterized compound accounted for 1.8% (unmixed soil) or 2.4% (mixed soil) of the total radioactivity after 85 weeks. Photodegradation on the soil surface is not therefore considered to be a major environmental degradation process for paraquat and no reliable estimates of the half-life of paraquat could be made (Day and Hemingway, 1981).

Environmental fate in water/sediment systems

Hydrolysis

Paraquat was dissolved in sterilized aqueous buffer solutions at pH 5, 7 and 9 to make a final concentration of approximately 91 mg/l and kept at 25 or 40°C in the absence of light. After 30 days, no significant decrease in concentration of paraquat was observed, indicating that under these conditions, paraquat was stable to hydrolysis (Upton *et al.*, 1985).

Aqueous photolysis

Aqueous photolysis of paraquat was examined by maintaining ring-labelled paraquat in sterilized 0.01 M phosphate buffer solution (28 mg/l) at 25°C and exposing it to a Xenon lamp equivalent to Florida summer sunlight (latitude 25-35°N) for 36 days. Duplicate samples were removed at intervals, together with duplicate dark control samples and 0-time samples. All the samples were analysed by TLC and HPLC. After 36 days of irradiation, the irradiated solution showed that 94% to 95% of the recovered radioactivity was due to unchanged paraquat. No radioactive photodegradation products were detected in the solutions but 0.13% of the original radioactivity was recovered as $^{14}CO_2$. It was therefore concluded that paraquat is relatively stable to photolysis in solution at pH 7 (Parker and Leahey, 1988).

In other study designed to determine the possible route of degradation of paraquat, solutions of [^{14}C]methyl- and [^{14}C]pyridyl-labelled paraquat were exposed to unfiltered UV light from a medium-pressure mercury lamp. Degradation was rapid and no paraquat remained after a 3-day irradiation. Carbon dioxide, methylamine and MINA were identified; MINA was shown to be degraded to carbon dioxide and methylamine when it was further irradiated (Slade, 1965).

Degradation in water/sediment systems

Degradation was studied using [U-^{14}C-dipyridyl]paraquat and two different water/sediment systems collected in Virginia Water (sandy loam) and Old Basing (loam) in England (Long *et al.*, 1996). Both systems were set up in cylindrical polycarbonate vessels in the dark at 20±2°C. Following acclimatization of the test systems, [^{14}C]paraquat in deionized water was applied to the water surface of each vessel at a rate equivalent to 1.1 kg/ha uniformly distributed in a 30 cm depth of water. Each test system was continuously aerated from above the air-water interface by drawing CO_2-free, humidified air through the system. Duplicate incubation units were removed for analysis at intervals of 0, 0.25, 1, 2, 7, 14, 30, 54 and 100 days after test substance application. Sediment was separated from the aqueous phase and extracted by digesting it with sulfuric acid at 130-150°C.

Even immediately after treatment, paraquat was strongly adsorbed to the sediment in the both systems. The distribution of radioactivity expressed as a percentage of the applied radioactivity in the two systems after 100 days incubation iwas shown in Table 11.

Table 11. Distribution of radioactivity in sediment and water after treatment with [U-^{14}C]pyridine-labelled paraquat (Long *et al.*, 1996).

Fraction	% of the applied radioactivity*	
	Virginia Water	Old Basing
Aqueous phase	0.2	0.1
Sediment, extracted	92.9	94.9
Sediment, unextracted	4.5	4.2
Volatile products	<0.1	<0.1
Total recovery	97.5	99.2
Paraquat found in sediment extract and aqueous phase	92.1	94.3

* Average values of the duplicate units.

Most of the radioactivity recovered from the aqueous phase and sediment extract was attributed to paraquat. No degradation products were detected. DT_{50} or DT_{90} could not be estimated as no significant degradation of paraquat was observed during the experiment.

Proposed degradation pathways in soil and water

When paraquat is applied to soil, it is strongly adsorbed and only gradually degraded. Some microorganisms, such as *Lipomyces starkeyi*, isolated from soils can degrade free paraquat completely. Unfiltered UV light also degrades paraquat to CO_2 and methylamine through MINA. Degradation first involves demethylation or oxidation of one pyridine ring, which leads to bridge cleavage and then ring cleavage of the remaining ring. Cleavage of the second ring results in the formation of methylamine and CO_2 by both microbial and photolytic routes. Hydrolysis was not considered to be a significant degradation process for paraquat.

The proposed degradation pathways of paraquat in soil and water are presented in Figure 5.

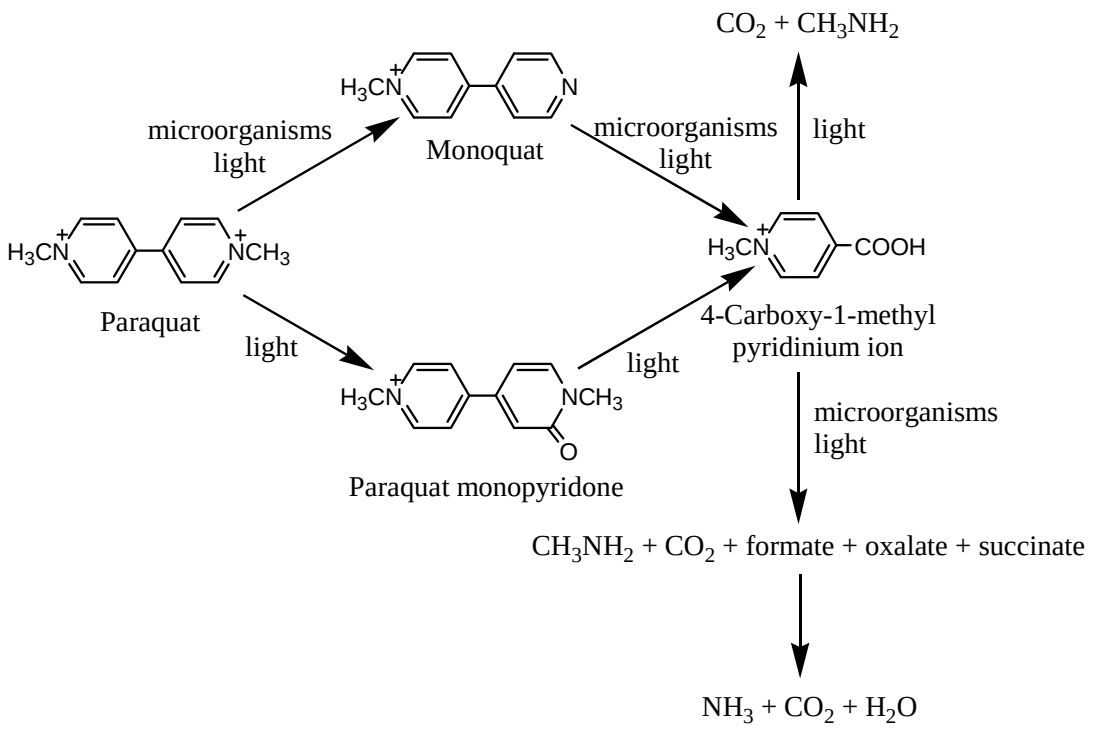


Figure 5. Proposed degradation pathways of paraquat by light and isolated microorganisms under laboratory conditions

Residues in succeeding crops

The Meeting received information on the uptake of paraquat by rotational crops.

A study was conducted in the UK to determine the nature and amount of paraquat residue uptake in rotational crops planted 0, 30, 120 and 360 days after soil treatment with paraquat (Vickers *et al.*, 1990). Seeds of wheat, lettuce and carrot were sown into individual pots containing a sandy loam soil 0, 30, 120 and 360 days after treating the soil in the pots with [2,2′,6,6′-^{14}C]paraquat at an application rate equivalent to 1.05 kg/ha. Seeds were also sown in control pots. At treatment, sowing and harvesting, cores of soil were taken to determine the magnitude and nature of the residues in the

soil. The pots were maintained in a glasshouse until the plants grew to maturity. Immature wheat and mature plants were harvested and the total radioactive residues were determined.

Over the course of the study, the total radioactive residues in the soil represented an average of 99.2% of that applied on the basis of combustion and liquid scintillation counting. TLC analysis of soil extracts accounted for 72.7-99.3% of the total radioactive residues as [^{14}C]paraquat, whose identity was confirmed by HPLC, but no other radioactive compounds were detected in any soil samples.

The total radioactive residues determined in fractions of harvested crops are shown in Table 12. Since the radioactive residues in all fractions of the crops sown up to 120 days after treatment were less than 0.01 mg paraquat equivalents/kg, the crops sown 360 days after treatment were not analysed.

Table 12. Total radioactive residues in succeeding crops (Vickers *et al.*, 1990).

Planting interval, days	Total radioactive residues, mg/kg paraquat equivalents						
	Wheat				Lettuce	Carrot	
	Immature	Grain	Straw	Chaff		Tops	Root
0	<0.0006	<0.0023	0.0040	<0.0043	0.0003	0.0005	0.0009
30	<0.0003	<0.0023	0.009	<0.0044	0.0003	0.0010	0.0003
120	0.0003	<0.0018	0.0030	<0.0036	<0.0010	<0.0003	0.0005

Another study was conducted also in the UK to isolate and characterize any residues present above 0.01 mg/kg in root and leafy vegetables after application of paraquat as a pre-emergence soil treatment at an exaggerated rate (Grout, 1994a). Seeds of lettuce and carrot were sown in pots containing sandy loam soil, immediately after which the soil was treated with [^{14}C]paraquat radiolabelled uniformly in both the pyridine rings at exaggerated rates of 14.3 and 14.7 kg/ha respectively, which correspond to approximately 13 times the highest current application rate. These crops were grown to maturity: lettuce was harvested 65 days after treatment and carrots 96 days after treatment. Analysis of the lettuce leaves and carrot roots at harvest showed that radioactive residues were below 0.005 mg-paraquat equivalents/kg (0.0034 and 0.0048 mg/kg respectively). The result indicates that there is no significant uptake of paraquat into rotational crops, even when the soil is treated at exaggerated rates.

RESIDUE ANALYSIS

Analytical methods

The Meeting received information on analytical methods for paraquat in a variety of fruits, vegetables, cereals, oil seeds and animal tissues, milk and eggs.

Methods 1B, RAM 252/01 and RAM 252/02 involve extraction of paraquat by refluxing homogeinized or comminuted samples in 0.5M sulphuric acid, filtration and clean-up by cation-exchange chromatography, conversion of paraquat to its coloured free radical with sodium dithionite, and spectrophotometric measurement within 5 minutes of addition of dithionite. They differ in the washing solutions used in the cation-exchange chromatography and their flow rates, and the spectrophotometric measurements. In Method 1B, absorption of the free radical is measured against a solution prepared with saturated ammonium chloride and sodium dithionite. In Methods RAM 252/01

and RAM 252/02, absorption is measured in second derivative mode against a paraquat standard. Second derivative spectrometry consists of calculating the first, second, or higher order derivatives of a spectrum with respect to wavelength or frequency and plotting this derivative rather than the spectrum itself. Usually the derivative is obtained by the spectrophotometer or associated electronics and plotted as the spectrum is scanned. A scanning spectrophotometer in the second derivative mode gives an enhanced response and increase selectivity, allowing the quantification of paraquat.

Since paraquat has been registered for many years, many analytical methods have been used for measuring its residues in plant and animal samples. Because paraquat has proved to be very stable in plants and animals, all the submitted methods are for determining paraquat only. These methods involve acid extraction of paraquat (not liquid samples), filtration and clean-up by cation-exchange chromatography from which paraquat is eluted with saturated ammonium chloride. Five methods further involve conversion of paraquat to its coloured free radical form using 0.2% (w/v) sodium dithionite in 0.3 M NaOH and spectrophotometric measurement. Three other methods determine paraquat in the cleaned up sample solution by reverse phase ion pair HPLC with UV detection at 258 nm.

Analytical methods for determining paraquat in plant and animal commodities for which MRLs may be set are presented below. The limits of quantification, recoveries and some other details of each method are summarized in Tables 11, 12 and 13.

Samples of plant origin

Kennedy (1986) developed a spectrophotometric method (Method 1B) for the determination of paraquat in vegetables, fruits, cereals and sugar cane juice. A diced, chopped or crushed plant sample (50–250 g) was refluxed in 0.5M sulphuric acid solution (total volume 500 ml in a 2 l capacity vessel) for 5 hours (one hour for sugar cane juice). The filtered digest was percolated through a column of cation-exchange resin (Duolite C225 (SRC 14), 52-100 mesh, sodium form, in a 25 ml burette) which retains paraquat and some of the natural crop constituents. The column was washed at a flow rate of 3-4 ml/min successively with deionized water (25 ml) 2.5% ammonium chloride solution (100 ml) and deionized water (25 ml). Paraquat was eluted with saturated ammonium chloride solution at a flow rate of about 1 ml/min and the first 50 ml of eluate was collected. A flow rate above 1.0 ml/min would adversely affect the recovery of paraquat. 10 ml of the eluate was treated with 2 ml of 0.2% sodium dithionite in 0.3M NaOH, which reduces paraquat to a free radical. The reaction mixture was inverted and rolled once or twice. Within 5 minutes of addition of sodium dithionite, the absorption in the range 360-430 nm was measured with a spectrophotometer against a solution prepared with saturated ammonium chloride and sodium dithionite, and a calibration curve relating the peak height at 396 nm to the concentration of paraquat in mg/l was drawn. The limit of quantification ranged between 0.01 and 0.05 mg/kg depending on crops and weight. The mean recovery was reported to be 60-95% but the fortification level was not reported although it was stated that the added amount should be similar to the amounts expected in the treated samples. Grout validated the method by analysing soya beans from soya plant treated at 8.2 kg ai/ha and potato tubers from a potato plant treated at 8.7 kg ai/ha, previously analysed in the metabolism study (Grout, 1994b; Grout, 1996) by Method 1B. The results from the two separate extraction methods, one in the soya/potato metabolism study (see above) and the other by Method 1B, gave equivalent residue levels: 0.705 and 0.840 mg/kg for the soya beans, and 0.079 and 0.072 mg/kg for the potato tuber, respectively. These results verify the extraction efficiency of Method 1B for these samples.

Method RAM 252/01, a second derivative spectrophotometric method, for potatoes, peas, beans, rape seed oil and oil cake was described by Anderson (year not specified) and validated by Coombe (1994b) and by Reichert (1996). Samples were processed as in Method 1B until the spectrophotometric analysis, except that the cation-exchange column was washed successively by deionized water (25 ml), 2M HCl (100 ml), deionized water (25 ml), 2.5% ammonium chloride solution (100 ml) and then deionized water (25 ml) at a flow rate of 5-10 ml/min. Oil seeds must be pulverized before analysis. The concentrations of the radical are measured by second derivative spectrophotometry

against paraquat standards in the range 380-430 nm. The limit of quantification ranged from 0.01 mg/kg and 0.5 mg/kg (rapeseed cake) and the mean recovery from 65 (rapeseed cake) to 87%. This method was also validated for potatoes, peas and beans by Reichert (1996); the mean recovery was 74-93%.

Method RAM 252/02 for vegetables, fruit, peas, beans, cereals, grass, oilseed or olive samples is the same as Method RAM 252/01 except that the flow rate of column washing is 3-5 ml/min. The limit of quantification ranged from 0.01 mg/kg to 0.5 mg/kg (oil seed cake), and the mean recovery from 67 to 87% (Anderson, 1995b).

In the currently used method, RAM 272/02, plant samples are processed in the same manner as Method RAM 252/02 until the eluate from the cation-exchange column is obtained. Ten ml of the eluate is cleaned up by passing through a preconditioned C18 SepPak solid phase extraction cartridge at a flow rate of approximately 1 ml/min allowing the first 5 ml to run to waste. A suitable volume of the second 5 ml is collected into an HPLC auto-sampler vial. Reverse phase ion pair HPLC is used for the determination of paraquat in the cleaned up sample solution. The HPLC conditions are as follows:

Column:	Hichrom Spherisorb S5P (phenyl)(250 mm x 4.6 mm i.d.)
Temperature:	40°C
Mobile phase:	Water:methanol (90:10) + 0.1% sodium-1-octanesulphonate + 1.0% diethylamine + 1.0% orthophosphoric acid
Flow rate:	1.5 ml/min
Injection volume:	100 to 200 µl depending on paraquat concentration in sample
Detection:	258 nm.

The paraquat concentration was calculated using single point calibration with a standard solution (0.1 µg/ml) or multiple point calibration with 0–1.0 µg/ml paraquat solutions. The limit of quantification ranged from 0.01 mg/kg to 0.05 mg/kg; and the mean recovery from 81 to 107% (Anderson, 1997). This method has been validated for crops by Anderson and Boseley in 1995 and by James in 1996, and again by Devine in 2001.

Anderson (1994a) developed Method RAM 254/01 for the determination of paraquat in liquid samples, such as milk and oil. An aliquot of oil (50 g) in a 500 ml bottle was mixed with deionized water (150 ml) and 3.5 g of cation-exchange resin conditioned by soaking it in saturated sodium chloride solution and thoroughly rinsing it with deionized water. Very viscous oil was warmed to 30°C. The bottle was rolled for 2 hours at 15-20 rpm. After carefully decanting as much oil as possible, the remaining resin was washed three times with 50 ml deionized water. Using deionized water, the resin was washed into a 25 ml burette. The column was washed at a flow rate of 3-5 ml/min with 2.5% ammonium chloride solution (200 ml) and then with deionized water (50 ml). Paraquat was eluted with saturated ammonium chloride solution at a flow rate of about 1 ml/min and the first 50 ml of eluate was collected. Paraquat was determined by second derivative spectrophotometry after converting it to the coloured free radical by mixing 10 ml of eluate with 2 ml of 0.2% (w/v) sodium dithionite in 0.3M NaOH and inverting and rolling the reaction mixture once or twice. Five minutes after adding the dithionite, the spectrum of the solution over the range of 360-430 nm was recorded using a scanning spectrophotometer in second derivative mode. As a confirmatory method, paraquat in water was analysed by reverse phase ion pair HPLC. The conditions of the HPLC were the same as those in Method RAM 272/02 except that the flow rate was 1.2 mlg/min. The limit of quantification was 0.05 mg/kg in oil in both spectrophotometric and HPLC methods. The mean recovery was 78% (n=6; RSD, 6%) at 0.05-0.50 mg/kg. An earlier method, Method 3B, determined paraquat with second derivative spectrometry only (Earl and Boseley, 1988).

Table 13. Limits of quantification of analytical methods for plant commodities.

Method & reference	Sample	LOQ, mg/kg
Method 1B Kennedy, 1986	Vegetables and fruits (250 g sample)	0.01
	Grain and seed (100 g)	0.02
	(50 g)	0.05
	Grass and straw (100 g)	0.02
	(25 g)	0.05
	Sugar cane juice (100 ml)	0.02
		0.01
Method RAM 252/01 Anderson (year not specified)	Fruits (250 g)	0.01
	Vegetables (250 g)	0.01
	Peas and beans (legumes) (100 g)	0.05
	Pulses (100 g)	0.05
	Potato (250 g)	0.01
	Cereals (100 g)	0.02
	Oil seed, cake (50 g)	0.5

Method & reference	Sample	LOQ, mg/kg
	Oil seed, oil (50 g)	0.05
Method RAM 252/02 Anderson, 1995	Fruits (250 g)	0.01
	Vegetables (250 g)	0.01
	Peas and beans (legumes) (100 g)	0.05
	Pulses (100 g)	0.05
	Potato (250 g)	0.01
	Cereals (100 g)	0.02
	Oil seed, cake (50 g)	0.5
	Oil seed, oil (50 g)	0.05
	Oil seed, whole seed (25 g)	0.05
Method RAM 272/01 Anderson & Boseley, 1997	Potato (100g)	0.01
	Bean (50 g)	0.05
	Barley (50 g)	0.02
	Rapeseed	0.05

Table 14. Procedural recoveries of paraquat in various analytical methods (plant samples).

Method & reference	Matrix	Fortification mg/kg	Recovery, %		No.	RSD %
			Mean	Range		
Method 1B Kennedy, 1986	Vegetables and fruits 250 g	Not reported		70-85		
	Grain and seeds 50 g			60-75		
	100 g			60-75		
	Grass and straw 25 g			80-95		
	100 g			70-85		
	Sugar-cane juice 100 ml			80-95		
	100 ml			80-95		
Method 1B Summary of procedural recoveries from a 1990 study (reported by Anderson (year not specified))	Apple	0.01-1.0	94		20	4
	Potato	0.01-1.0	83		20	4
	Vine	0.01-1.0	76		20	10
	Strawberry	0.01-1.0	93		20	3
	Cabbage	0.01-1.0	74		20	10
Method RAM 252/01 Coombe, 1994b	Potato	0.01-0.50	87	81-92	6	4
	Pea	0.01-0.50	75	72-81	6	4
	Bean	0.05-0.50	79	74-83	10	3
	Rapeseed oil, extracted	0.05-0.50	78	74-87	6	6
	Rapeseed cake	0.10-10.0	65	63-77	6	2
Method RAM 252/01 Reichert, 1996	Potato	0.01-0.05	74	69-85	4	10
	Pea	0.05-0.10	99	94-105	4	5
	Bean	0.05-0.50	93	74-117	6	19
Method RAM 252/02 Anderson, 1995b	Potato	0.01-0.50	87	81-92	6	4
	Bean	0.05-0.50	79	74-83	10	3
	Pea	0.05-0.50	75	72-81	6	4
	Rapeseed, oil	0.05-0.50	78	74-87	6	6
	Rapeseed, cake	0.10-10.0	67	63-77	6	6
	Rapeseed, whole seed	0.05-2.0	80		10	9
	Sunflower seed, whole seed	0.05-2.0	84		10	8
Method RAM 252/02 Summary of procedural recoveries obtained since 1989 from GLP studies (reported by Anderson, 1995)	Apple	0.05-0.5	92		8	5
	Pear	0.05	92		4	1
	Cherry	0.05	97		4	1
	Peach	0.05	96		4	2
	Plum	0.05	92		2	1
	Grape	0.05-0.1	89		8	2
	Palm oil	0.05	80		6	3
	Olive oil	0.1	67		6	13
	Olive cake	0.05	77		5	14
	Potato	0.05-0.2	85		6	5
	Wheat grain	0.1	88		4	2

Method & reference	Matrix	Fortification mg/kg	Recovery, %		No.	RSD %
			Mean	Range		
	Wheat straw	0.1-0.2	78		3	6
	Rice grain	0.05-0.1	89		2	2
	Rice straw	0.05	87		2	3
	Maize cob	0.05-0.1	86		2	3
	Maize silage	0.05-0.1	80		2	0
	Cocoa bean	0.05-0.1	80		14	9
	Coffee bean	0.05-0.5	61		4	8
	Lucerne	5.0-30	99		6	4
Method RAM 272/02 Anderson & Boseley, 1995 Also reported by Anderson, 1997	Potato	0.01-0.05	87	78-94	10	7
	Barley	0.02-1.0	81	74-93	10	8
	Broad bean	0.05-0.50	95	82-93	10	10
	Rapeseed	0.05-2.0	107	88-126	10	11
Method RAM 272/02 Devine, 2001	Orange	0.01-0.10	99	90-109	10	9
	Tomato	0.01-0.10	94	82-105	10	8
	Rapeseed	0.05-0.50	71	64-78	10	9
	Wheat straw	0.05-0.50	90	77-98	10	8
Method RAM 272/02 James, 1996	Potato	0.01-0.2	92	70-102	8	15
	Rapeseed	0.05-1.0	93	87-98	10	3

Samples of animal origin

Earl and Boseley (1988) developed Method 4B, for determining paraquat in eggs and animal tissues. Tissue (25 g) is sliced, minced, and then homogenized with 50 ml of 10% trichloroacetic acid solution. Eggs should be thoroughly thawed and mixed before homogenization. After centrifugation, the solid is re-extracted with two further portions of 10% trichloroacetic acid solution. Supernatants from each centrifugation are combined. Fat in milk, skin with subcutaneous fat and fat samples should be removed by hexane extraction before cation-exchange. The combined supernatant is filtered to remove fine particles, then diluted with deionized water to 500 ml and percolated through a column of cation-exchange resin (particle size 0.15-0.30 mm, 52-100 mesh, sodium form; packed in a 25 ml burette) which retains paraquat and some of the natural tissue constituents. The column is washed at a flow rate of 3-4 ml/min successively with deionized water (25 ml), 2.5% ammonium chloride (100 ml) and deionized water (25 ml) to removed endogenous materials. Paraquat is eluted with saturated ammonium chloride solution at a flow rate of about 1 ml/min and the first 50 ml of eluate collected. A flow rate above 1.0 ml/min would adversely affect the recovery of paraquat. Paraquat is determined by reverse phase ion pair HPLC as in RAM 272/02.

The paraquat concentration was calculated using a linear calibration prepared with 0–1.0 µg/ml paraquat solutions. The limit of quantification was 0.005 mg/kg for egg and bovine and ovine tissue samples. The mean recovery ranged from 75 to 90% but fortification levels were not reported although it was stated that the added amount should be similar to the amounts expected in the treated samples.

Method RAM 254/01 (Anderson, 1994a) is also applicable to milk. An aliquot of milk (1000 ml) in a 2 l bottle is treated in the same manner as oil (see above). The limit of quantification was reported for water at 0.0001 mg/l but not for milk. No results of recovery test on milk were reported.

Methods for the determination of paraquat residues in the tissues of wildlife were developed and validated (Green, 1994). The method involves the measurement of the absorbance of a product formed using an ELISA kit. Paraquat was determined from a calibration curve. Positive detects were confirmed by HPLC with UV detection at 286 nm.

The current method, RAM 004/07, for determining paraquat in animal tissue samples and fluids, such as muscle, liver, kidney, fat, skin, milk and eggs, was developed and validated by Anderson (1994b, 1997). It is essentially similar to Method 4B. Anderson reported the limit of quantification to be 0.005 mg/kg for egg and chicken tissue samples. This method was also validated by Coombe (1994a) and Devine (2001b) (Table 15). The mean recoveries in these validation studies ranged from 77 to 105%.

Table 15. Procedural recoveries of paraquat in Method RAM 004/07 (animal samples).

Reference	Sample	Fortification mg/kg	Recovery, %		No.	RSD %
			Mean	Range		
Anderson, 1994b, 1997	Chicken muscle	0.005-0.50	89	77-96	12	7
	Chicken skin & subcutaneous fat	0.005-0.50	90	82-99	12	6
	Chicken liver	0.005-0.50	85	70-95	12	9
	Chicken fat	0.005-0.50	84	65-101	12	13
	Whole hen egg	0.005-0.50	86	72-101	12	12
	Hen egg yolk	0.005-0.50	81	60-96	12	13
	Hen egg white	0.005-0.50	92	84-96	12	4
Devine, 2001	Milk	0.005-0.05	105	101-110	10	2
	Kidney	0.005-0.05	77	71-86	10	7
Coombe, 1994a	Liver	0.01-0.05	95	89-99	4	5
	Fat	0.01-0.05	88	84-90	4	3
	Whole egg	0.01-0.05	94	86-103	4	8

The currently used methods, RAM 272/02 for plant samples and RAM 004/07 for animal samples, were found to be suitable for the quantification of paraquat in plant and animal commodities. These methods were fully validated and include confirmatory techniques. The earlier methods for the quantification of paraquat in plant and animal samples were also found to be suitable by validation, but mean recoveries were below 70% from rape seed cake, olive oil, and coffee beans.

Stability of pesticide residues in stored analytical samples

The Meeting received data on the stability of residues in ground samples of prunes, banana, cabbage, potato, carrot, tomato, maize (grain, forage, fodder and silage), wheat grain, coffee bean and birdsfoot trefoil (forage and hay) as well as meat, milk and eggs stored at a temperature below -15°C.

Plant samples

Stability was assessed using fortified samples in prunes, banana, cabbage, potato, carrot, tomato, maize (grain, fodder, forage and silage), wheat grain, and coffee bean, and incurred residues in birdsfoot trefoil forage and hay. Crop samples were frozen within 1-3 hours of harvest or purchase and kept frozen until grinding. Frozen or fresh samples were ground and the ground samples were stored in glass jars (sealed with plastic lined paper bag and screw cap), plastic lined paper bags or polyethylene containers in deep freeze conditions (<-15°C) corresponding to actual storage conditions for these crop samples for about 2 years, except that bananas and coffee beans were stored for about one year and cabbages and carrots up to 46 months. Paraquat was determined by second derivative spectrophotometric methods. Procedural recoveries were checked by analysing untreated samples fortified with known amounts of paraquat.

Table 16 shows the stability of paraquat residues in plant commodities stored over time at <-15°C. Residue data are not corrected for recovery. No decrease of residues of paraquat, whether fortified or incurred, was observed during the test periods, the longest being 46 months, except a slight decrease in birdsfoot trefoil forage which had been treated at a rate equivalent to 0.54 kg ai/ha and contained incurred residues at 57 mg/kg.

Table 16. Storage stability of paraquat[1] in fortified plant samples stored at <15°C.

Prune					
Storage days	Paraquat after fortification & storage, mg/kg		Proc. recovery%	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg	Fortification, 0.20 mg/kg			
0	0.09	0.19	92	0.05	Roper, 1991c
28	0.08	0.17	77		
90	0.08	0.17	89		
181	0.08	0.17	89		
365	0.09	0.18	100		
561	0.08	0.17	97		
762	0.08	0.18	93		
Banana					
Storage days	Paraquat after fortification & storage, mg/kg (average of triplicate samples)		Proc. recovery %	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg				
0	0.09		90	0.05	Coombe, 1995a
50	0.09		91		
97	0.09		93		
209	0.09		88		
363	0.09		93		
Cabbage					
Storage days	Paraquat after fortification & storage, mg/kg (average of triplicate samples)		Proc. recovery %	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg				
0	0.12		109	0.05	Anderson, 1995a
32	0.11				
106	0.11				
168	0.11				
364	0.12				
538	0.11				
720	0.11				
1378	0.16				
Carrot					
Storage days	Paraquat after fortification & storage, mg/kg (average of triplicate samples)		Proc. recovery %	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg				
0	0.10		104	0.05	Anderson, 1995a
31	0.10				
106	0.10				
168	0.10				
370	0.10				
535	0.10				
722	0.11				
1380	0.12				
Potato					
Storage days	Paraquat after fortification & storage, mg/kg		Proc. recovery%	LOQ mg/kg	Reference
	Fortification, 0.05 mg/kg	Fortification, 0.10 mg/kg			
0	0.03	0.09	84	0.025	Roper, 1991b
29	0.04	0.09	88		
92	0.04	0.10	90		
182	0.04	0.10	92		
365	0.04	0.08	110		
585	0.04	0.09	89		
798	0.04	0.10	95		
Tomato					
Storage days	Paraquat after fortification & storage, mg/kg		Proc. recovery%	LOQ mg/kg	Reference
	Fortification, 0.4 mg/kg	Fortification, 0.10 mg/kg			
0	0.04	0.08	66	0.025	Roper, 1991a
29	0.04	0.09	82		
92	0.04	0.09	92		
182	0.04	0.10	92		
365	0.05	0.10	80		

582	0.04	0.10	92		
763	0.05	0.10	95		
Maize Grain					
Storage days	Paraquat after fortification & storage, mg/kg		Proc. recovery %	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg	Fortification, 0.20 mg/kg			
0	0.09	0.17	68	0.05	Roper, 1991d
30	0.09	0.16	83		
92	0.09	0.17	93		
184	0.09	0.18	89		
366	0.09	0.17	87		
589	0.08	0.17	93		
806	0.09	0.17	83		
Maize Fodder					
Storage days	Paraquat after fortification & storage, mg/kg		Proc. recovery %	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg	Fortification, 0.20 mg/kg			
0	0.08	0.17	81	0.05	Roper, 1991e
30	0.09	0.17	83		
92	0.09	0.17	82		
184	0.08	0.17	82		
366	0.09	0.17	93		
580	0.08	0.16	77		
798	0.08	0.17	94		
Maize Forage					
Storage days	Paraquat after fortification & storage, mg/kg		Proc. recovery%	LOQ mg/kg	Reference
	Fortification, 0.05 mg/kg	Fortification, 0.10 mg/kg			
0	0.04	0.09	100	0.025	Roper, 1991g
30	0.04	0.09	96		
92	0.04	0.08	106		
184	0.04	0.09	91		
366	0.04	0.08	83		
581	0.04	0.08	90		
801	0.05	0.09	86		
Maize Silage					
Storage days	Paraquat after fortification & storage, mg/kg		Proc. recovery%	LOQ mg/kg	Reference
	Fortification, 0.05 mg/kg	Fortification, 0.10 mg/kg			
0	0.04	0.09	90	0.025	Roper, 1991f
30	0.04	0.08	86		
92	0.04	0.08	92		
184	0.04	0.09	91		
366	0.04	0.08	90		
590	0.04	0.08	93		
800	0.04	0.08	100		
Wheat grain					
Storage days	Paraquat after fortification & storage, mg/kg (average of triplicate samples)		Proc. recovery %	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg				
0	0.10		99	0.05	Anderson, 1995a
29	0.09				
102	0.10				
167	0.09				
360	0.10				
533	0.10				
730	0.11				
Coffee bean					
Storage days	Paraquat after fortification & storage, mg/kg (average of triplicate samples)		Proc. recovery %	LOQ mg/kg	Reference
	Fortification, 0.10 mg/kg				
0	0.09		99	0.05	Coombe, 1995a
50	0.09		91		
97	0.09		94		
215	0.09		90		
377	0.09		96		
Birdsfoot Trefoil Forage and Hay with Incurred Residue					

Storage weeks	Paraquat in treated crop sample after storage, mg/kg		Proc. recovery%	LOQ mg/kg	Reference
	Incurred, 57 mg/kg (Forage)	Incurred, 200 mg/kg (Hay)			
0	57	200	104	5	Roper, 1991h
12	55	178	89		
25	52	167	86		
57	48	207	91		
104	41	234	84		

[1] Residues in Birdsfoor Trefoil forageand hay were incurred

Animal samples

The storage stability of paraquat was examined in meat, milk, and eggs. Samples of chicken muscle after mincing, and eggs after thorough mixing were fortified with paraquat at 0.10 mg/kg and stored at <-18°C for up to 863 days (28 months). Milk was fortified at 0.1 mg/l and stored for 391 days. These conditions represent actual storage conditions of animal commodities subject to residue analysis. At predetermined intervals, triplicate samples were taken out for analysis. Hen muscle and egg samples were analysed by Method 4B and milk samples by a second derivative spectrophotometric method. The limit of quantification was 0.005 mg/kg.

Table 17 shows the results. Residue data are not corrected for recovery. No decrease of residues of paraquat was observed under storage for up to 28 months. These test matrices represent a diverse selection of animal tissues and demonstrate the stability of paraquat under various fortified animal sample storage conditions. However, the chicken egg and milk samples showed relatively low procedural recoveries.

Table 17. Storage stability of paraquat in animal samples fortified with paraquat and stored at <-18°C.

Storage Days	Chicken muscle fortified at 0.10 mg/kg		Chicken eggs fortified at 0.10 mg/kg		Milk fortified at 0.01 mg/l	
	Paraquat, mg/kg[1]	Proc. recovery, %	Paraquat, mg/kg[1]	Proc. recovery, %	Paraquat, mg/l[1]	Proc. recovery, %
0	0.08	83	0.08	75	0.010	80
31	0.10	83	0.07	75		
42					0.007	76
89					0.008	75
91			0.08	75		
92	0.08	83				
161	0.07	83				
178			0.07	75		
202					0.007	75
276	0.09	83				
391					0.007	73
405	0.09	83				
426			0.08	75		
560	0.09	83				
581			0.08	75		
843	0.08	83				
863			0.09	75		
-	Ref: Anderson *et al.*, 1991a		Ref: Anderson *et al.*, 1991b		Ref : Coombe, 1995b	

[1] Not adjusted for procedural recovery.

USE PATTERN

Paraquat, normally available as the dichloride or bis(methyl sulfate) salt, is registered in many countries to control weeds and permitted for use on a wide range of crops, including orchard and plantation uses,

row crops and pasture, pre-plant, pre-emergence or post-emergence. The main uses of paraquat in food crops in many countries are as a non-selective herbicide. It is also registered for use as a pre-harvest desiccant (or harvest aid).

Registered uses of paraquat are very broad and are generally based on the range and size of the weeds to be controlled rather than the crop type or growth stage. As paraquat is a non-selective contact herbicide, use recommendations stress the need to shield any crops present at the time of spraying, in order to avoid phytotoxicity or crop damage. However, applications can be made to the base of bushes and trees without damage to the crop, as the bark and woody stems are resistant to paraquat.

The information available to the Meeting on uses on fruits, vegetables, cereals, tree nuts and oil seeds in Argentina, Australia, Brazil, India, Italy, Japan, Peru, the UK, the USA and Uruguay is summarized in Table 18XX. The weight of active ingredient is expressed on a paraquat cation basis. The formulation referred to in recommended uses is the soluble concentrate (SL).

Table 18. Registered uses of paraquat.

Crops	Country	Formulation Conc. g ai/l	Application				
			Use/Method	Max rate l/ha	Max rate kg ai/ha		
FRUITS							
Orchard fruits (incl. banana & vineyard)	Australia	250	Directed spray	3.2	0.8		-
Orchard fruits (incl. banana & vineyard)	Brazil	200	Directed spray	3.0	0.6	1	1
Orchard fruits (all)	Japan	36.2 (diquat, 37.5)	Directed spray	20	0.72	5	30
Orchard fruits (incl. vineyard)	Uruguay	200	Directed spray	3	0.6		-
Citrus Fruits							
Citrus fruits	Italy	200	Inter-row	5	1		
Citrus fruits	USA	360	Directed spray	3.2	1.14		-
Orange	Peru	200	Directed spray	3	0.6		2
Pome fruits							
Pome fruits	Italy	200	Inter-row	5	1		
Pome fruits	UK	120 (diquat, 80)	Directed spray	5.5	0.66	1	-
Pome fruits	USA	360	Directed spray	3.2	1.14		-
Stone fruits							
Peach	USA	360	Directed spray	3.2	1.14	3	14
Stone fruits	Italy	200	Inter-row	5	1		
Stone fruits	UK	120 (diquat, 80)	Directed spray	5.5	0.66	1	-
Stone fruits (excl. peach)	USA	360	Directed spray	3.2	1.14	3	28
Berries and other small fruits							
Cane fruits	UK	120 (diquat, 80)	Pre-plant	5.5	0.66	1	-
Cane fruits	USA	360	Postemergence directed spray	3.2	1.14		-
Grape	Italy	200	Inter-row	5	1		
Grape	Peru	200	Directed spray	3	0.6		2
Grape	USA	360	Directed spray	3.2	1.14		-

Crops	Country	Formulation Conc. g ai/l	Application				
			Use/Method	Max rate l/ha	Max rate kg ai/ha		
Strawberry	Japan	36.2 (diquat, 37.5)	Pre-plant	10	0.36	1	
Strawberry	UK	120 (diquat, 80)	Directed spray	5.5	0.66	1	-
Strawberry	USA	360	Postemergence directed spray	1.5	0.55	3	21
Other fruits							
Olive	Brazil	200	Directed spray	3.0	0.6	1	7
Olive	Italy	200	Inter-row, harvesting aid	5	1		40
Olive	USA	360	Directed spray	3.2	1.14	4	13
Banana	Peru	200	Directed spray	3	0.6		2
Banana	USA	360	Directed spray	3.2	1.14		-
Guava	USA	360	Directed spray	2.9	1.05		-
Kiwi	USA	360	Directed spray	3.2	1.14	3	14
Passion fruit	USA	360	Directed spray	2.9	1.05		-
VEGETABLES							
Vegetables (except potato, legumes & pulses)	Australia	250	Directed spray	2.4	0.6		-
Bulb vegetables							
Garlic	USA	360	Preplant/ pre-emergence	3.2	1.14	1	60†5
Onion	USA	360	Preplant/ pre-emergence	3.2	1.14	1	60†5
Onion, bulb	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Welsh onion	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Brassica vegetables							
Brassica vegetables	USA	360	Preplant pre-emergence	3.2	1.14		-
Broccoli	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Cabbage	Brazil	200	Pre-plant	3.0	0.6	1	1
Cabbage	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Cauliflower	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Chinese cabbage	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Fruiting vegetables							
Fruiting vegetables (excl. tomato and peppers)	USA	360	Preplant pre-emergence	3.2	1.14		-
Cucumber	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	14
Melon	Japan	36.2 (diquat, 37.5)	Pre-plant	10	0.36	1 (3)	
Pumpkin	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	14
Watermelon	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	1 (3)	-
Peppers	USA	360	Directed spray	1.5	0.55	3	-

Crops	Country	Formulation Conc. g ai/l	Application				
			Use/Method	Max rate l/ha	Max rate kg ai/ha		
Peppers, sweet	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	14
Tomato	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	14
Tomato	USA	360	Preplant pre-emergence	3.2	1.14		30
Tomato	USA	360	Directed spray	1.5	0.55	3	30
Tomato	Uruguay	200	Directed spray	3	0.6		
Leafy vegetables							
Collard	USA	360	Preplant pre-emergence	3.2	1.14		-
Lettuce	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Lettuce	USA	360	Preplant pre-emergence	3.2	1.14		-
Spinach	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	14
Legume vegetables and Pulses							
Beans	Brazil	200	Pre-plant	3.0	0.6	1	1
Beans (Lima, Snap)	USA	360	Preplant pre-emergence	3.2	1.14		-
Beans, dry	Argentina	200	Pre-harvest desiccant	2.0	0.4	1	-
Chickpea	Australia	250	Over-the-top spray	0.8	0.2		14
Faba bean	Australia	250	Over-the-top spray	0.8	0.2		14
Field bean	Australia	135 (diquat 115)	Pre-plant	2.4	0.32		
Field pea	Australia	250	Over-the-top spray	0.8	0.2		14
Legume and pulses	Uruguay	200	Desiccation	2	0.4	1	5
Lentil	Australia	250	Over-the-top spray	0.8	0.2		14
Lentil, dry	Argentina	200	Pre-harvest desiccant	2.0	0.4	1	-
Mung bean	Australia	135 (diquat 115)	Pre-plant	2.4	0.32		
Navy bean	Australia	135 (diquat 115)	Pre-plant	2.4	0.32		
Pea	USA	360	Preplant pre-emergence	3.2	1.14		-
Peas, dry	Argentina	200	Pre-harvest desiccant	2.0	0.4	1	-
Pigeon pea	Australia	135 (diquat 115)	Pre-plant	2.4	0.32		
Pulses (excluding soya bean)	USA	360	Harvest aid	1.5	0.55	2†3	7
Soya bean, dry	Argentina	200	Pre-harvest desiccant	2.0	0.4	1	-
Soya bean	Australia	135 (diquat, 115)	Pre-plant	3.2	0.43		
Soya bean	Brazil	200	Pre-plant	3.0	0.6	1	7
Soya bean	Brazil	200	Desiccation	2.5	0.5	1	7
Soya bean	USA	360	Preplant or pre-emergence.	3.2	1.14	†9	-
Soya bean	USA	360	Postemgence directed spray	0.39	0.14	2†10	-

Crops	Country	Formulation Conc. g ai/l	Application				
			Use/Method	Max rate l/ha	Max rate kg ai/ha		
Soya bean	USA	360	Harvest aid	0.78	0.28		15
Soya bean	Uruguay	200	Directed spray	3	0.6		-
Root and tuber vegetables							
Beet	Brazil	200	Pre-plant	3	0.6	1	7
Carrot	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Potato	Argentina	200	Pre-harvest desiccant	2.5	0.5	1	7
Potato	Australia	250	Over-the-top spray	1.6	0.4	1	-
Potato	Australia	135 (diquat, 115)	Over-the-top spray	3.2	0.43	1	-
Potato	Australia	250	Pre-harvest weed control	2.8	0.7	1	†1
Potato	Brazil	200	Pre-plant	3.0	0.6	1	7
Potato	Brazil	200	Desiccation	2.5	0.5	1	7
Potato	Japan	36.2 (diquat, 37.5)	Pre-germination	6	0.22	1	90
Potato	Peru	200	Harvest aid	3	0.6	1	7
Potato	UK	120 (diquat, 80)	Pre-emergence	5.5	0.66	1	-
Potato	Uruguay	200	Directed spray	3	0.6		-
Potato	Uruguay	200	Desiccation	2	0.4	1	5
Potato	USA	360	Preplant or pre-emergence broadcast	1.5	0.55		-
Potato (fresh market only)	USA	360	Broadcast (for pre-harvest vine killing and weed desiccation)	1.2	0.42	†6	3
Root and tuber vegetables (excl. potato)	USA	360	Preplant pre-emergence	3.2	1.14		-
Sugar beet	Uruguay	200	Directed spray	3	0.6		-
Sweet potato	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Stalk and stem vegetables							
Asparagus	Brazil	200	Pre-plant	3.0	0.6	1	1
Asparagus	Japan	36.2 (diquat, 37.5)	Pre-plant, inter-row	10	0.36	3	30
Asparagus	USA	360	Pre-plant or pre-emergence broadcast or banded over-row	3.2	1.14		-
Asparagus (≥ 2 y)	USA	360	Broadcast or Banded Over-Row	3.2	1.14		6
CEREALS							
Maize	Argentina	200	Pre-harvest desiccant	2.0	0.4	1	-
Maize	Australia	135 (diquat 115)	Pre-plant	2.4	0.32		
Maize	Brazil	200	Pre-plant	3.0	0.6	1	7
Maize	Brazil	200	Desiccation	2.5	0.5	1	7

Crops	Country	Formulation Conc. g ai/l	Application				
			Use/Method	Max rate l/ha	Max rate kg ai/ha		
Maize	USA	360	Preplant or Pre-emergence broadcast or banded over row	3.2	1.14		-
Maize	USA	360	Postemergence directed spray	1.5	0.55		-
Maize	Uruguay	200	Directed spray	3	0.6		-
Rice	Argentina	200	Pre-harvest desiccant	2.0	0.4	1	5
Rice	Australia	250	Pre-sowing	1.6	0.4		
Rice	Australia	135 (diquat, 115)	Pre-crop emergence	3.2	0.43		
Rice	Brazil	200	Pre-plant	3.0	0.6	1	7
Rice	Brazil	200	Desiccation	2.5	0.5	1	7
Rice	Japan	36.2 (diquat, 37.5)	Pre-plant	10	0.36	1	-
Rice	Peru	200	Directed spray	3	0.6		2
Rice	USA	360	Preplant or pre-emergence broadcast	3.2	1.14		-
Rice	Uruguay	200	Desiccation	1	0.2	1	7
Sorghum	Argentina	200	Pre-harvest desiccant	2.0	0.4	1	5
Sorghum	Australia	135 (diquat, 115)	Pre-plant	3.2	0.43		
Sorghum	Brazil	200	Pre-plant, inter-row	3.0	0.6	1	7
Sorghum	Brazil	200	Desiccation	2.5	0.5	1	7
Sorghum	USA	360	Preplant or pre-emergence broadcast	3.2	1.14		†7
Sorghum	USA	360	Postemergence directed spray	1.5	0.55	2†8	†7
Sorghum	Uruguay	200	Directed spray	3	0.6		-
Sorghum	Uruguay	200	Desiccation	1	0.2	1	7
TREE NUTS							
Hazelnut	Italy	200	Inter-row, harvesting aid	5	1		40
Pistachio	USA	360	Directed spray	3.2	1.14		7[†11]
Tree nuts (excl. pistachio)	USA	360	Directed spray	3.2	1.14		-
Walnut	Italy	200	Inter-row	5	1		
OILSEEDS							
Cotton	Argentina	200	Defoliant	1.0	0.2	1	-
Cotton	Australia	135 (diquat, 115)	Pre-harvest desiccant	1.6	0.22	1	7
Cotton	Brazil	200	Pre-plant, inter-row	3.0	0.6	1	7
Cotton	Brazil	200	Deciccation	2.5	0.5	1	7
Cotton	Uruguay	200	Directed spray	3	0.6		-
Cotton	USA	360	Preplant or Pre-emergence	3.2	1.14		-
Cotton	USA	360	Harvest aid	1.5	0.55	†2	3
Sunflower	Argentina	200	Pre-harvest desiccant	2.5	0.5	1	-
Sunflower	Australia	135 (diquat, 115)	Pre-plant	3.2	0.43		

Crops	Country	Formulation Conc. g ai/l	Application				
			Use/Method	Max rate l/ha	Max rate kg ai/ha		
Sunflower	Uruguay	200	Desiccation	1	0.2	1	7
Sunflower	USA	360	Preplant or pre-emergence broadcast or banded over row	3.2	1.14		-
Sunflower	USA	360	Desiccation	1.5	0.55		7
DRIED HERBS							
Hop	Australia	250	Directed spray	1.6	0.4		-
Hop	UK	120 (diquat, 80)	Directed spray for weed control and stripping	5.5	0.66	1	-
Hop	USA†4	360	Directed spray and/or suckering and stripping	1.5	0.55	3	14
TEA							
Tea	Brazil	200	Directed spray	3.0	0.6	1	7
Tea	India	200	pre-emergence or post-emergence directed between rows	4.25	0.75	1	-
Tea	Japan	36.2 (diquat, 37.5)	Inter-row	10	0.36	3	7
Tea	Peru	200	Directed spray	3	0.6		2

GAP of Japan: PHI applicable for inter-row application only; “1 (3)” indicates that the formulation containing diquat can be applied only once while paraquat can be applied up to three times.

†1, Applied 3 to 7 days before digging crop after all tops have died down.
†2, Repeat application if necessary. Do not exceed a total of 1.5 l/ha as a harvest aid.
†3, Not registered for use on dry beans in California. Not to make more than 2 applications or exceed a total of 1.5 l/ha.
†4, Indiana, Oregon and Washington states only.
†5, Preharvest interval for California only, 200 days
†6, Do not exceed 2.3 l/ha per season. Split applications must be applied a minimum of five days apart. Use only in the states of: Colorado, Delaware, Idaho, Illinois, Indiana, Kansas, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Nevada, New Jersey, New York, North Dakota, Ohio, Oregon, Pennsylvania, South Dakota, Utah, Washington, Wisconsin and Wyoming.
†7, PHI: 48 days for grain and 20 days for forage.
†8, Do not exceed 2 postemergence-directed applications or exceed a total of 2.5 l per season.
†9, Do not exceed 1.9 l per season.
†10, If needed make a second and final application 7-14 days later.
†11, Do not exceed 2 applications after shells split.

Table 19. Summary of uses of paraquat in food crops.

Use	Crops	Rate, kg ai/ha	No	Pre-harvest/Pre-sowing interval (days)
Pre-planting or pre-sowing of crops	None present at time of treatment	0.3-0.8	1	4 hours-1 day
Post-sowing but pre-emergence	None present at time of treatment	0.3-1.1	1	1-3 days before emergence
Early post-emergence	Potatoes	0.4-1.1	1-2	Up to 10% emergence for early and seed potatoes, up to 40% emergence for main crop potatoes
Inter-row weeding	Soft fruits, berries, nuts, cane	0.4-1.1	1-2	Apply to soil at base of trees or

Use	Crops	Rate, kg ai/ha	No	Pre-harvest/Pre-sowing interval (days)
(post-emergence directed)	fruits; citrus, pome and stone fruits; grapes, maize; plantations			bushes or use directed or guarded sprays
Post harvest treatment of soil	Strawberries, asparagus, hops, grass for seed	0.4-0.8	1-2	N/A
Desiccation or Harvest aid	Maize, cotton, potato, legumes & pulses, soybean, sunflower, sorghum	0.2-0.6	1-2	3-15 days PHI

RESIDUES RESULTING FROM SUPERVISED TRIALS ON CROPS

Laboratory reports of trials included method validation with recovery experiments conducted at levels similar to those occurring in samples from the supervised trials. Dates of analyses or duration of sample storage were also provided. Most reports provided information on the lot size, weather, methods of application, weights and volumes, application dates, residue sample sizes and sampling dates. However, some very old trials were reported only in summary formats without sufficient details.

Residue data are recorded as mg paraquat cation/kg and not corrected for recovery. The formulation used in supervised trials was the soluble concentrate (SL). In most cases paraquat dichloride was used but in some cases the bis(methyl sulfate) was used.

Residue values from the trials conducted according to GAP were used for the estimation of maximum residue levels. These results are double-underlined. However, when all trials resulted in nil residues, results from trials according to GAP were not so marked.

Table number	Crop
20	Citrus fruits (lemon, lime and orange)
21	Pome fruits (apple and pear)
22	Stone fruits (cherry, peach and plum)
23	Berries and other small fruits (grape; blueberry; currant, black and red; gooseberry; raspberry; longanberry, strawberry)
24	Olive
25	Assorted tropical and sub-tropical fruits – inedible peel (banana, guava, kiwifruit and passion fruit)
26	Bulb vegetables (onion)
27	Brassica vegetables (broccoli, Brussels sprouts, cabbage, cauliflower and Chinese cabbage)
28	Fruiting vegetables, Other than cucurbits (peppers and tomato)
29	Fruiting vegetables, Cucurbits (cucumber, melon, summer squash)
30	Leafy vegetables (kale, lettuce and turnip tops)
31	Legume vegetables and pulses (beans, broad bean, chick peas, field beans, field peas, peas and soya beans)
32	Root and tuber vegetables (beet, carrot, parsnip, scorzonera, sugar beet, swede and turnips, potato)
33	Stalk and stem vegetables (artichoke, asparagus and celery)
34	Maize
35	Sorghum
36	Rice
37	Tree nuts (almond, hazelnut, macadamia nut and pecan)
38	Cotton seed
39	Sunflower seed
40	Hops
41	Tea

42	Soya forage and hay or fodder
43	Sugar beet tops
44	Maize forage and fodder
45	Sorghum forage (green) and straw and fodder, dry
46	Rice straw and fodder, dry
47	Almond hulls
48	Cotton fodder

Citrus fruits

Paraquat is used to control weeds around the base of citrus fruit trees.

Numerous supervised residue trials over several seasons and locations have been carried out on navel oranges in California, the USA, and on Valencia oranges, Hamlin oranges, limes, lemons and grapefruit in Florida, the USA. Paraquat was applied at rates of 1.12 to 2.8 kg ai/ha from one to 17 times (total applications in three years) and, in one series of trials, at an excessive rate (33.6 kg ai/ha), to control weeds by broadcast application under the fruit trees. Fruits were harvested, in some cases immature, from 0 to 177 days after the last application. In the case of the very high application rate, immature fruit were harvested 35 and 346 days and mature fruit 152 days after application.

Two residue trials in Italy and numerous trials in the USA have been conducted in which paraquat was applied as an inter-row treatment in orange orchards at a rate of 0.8 kg ai/ha.

Table 20. Paraquat residues in citrus fruits from supervised trials in Italy and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
ORANGE								
CA, USA, 1962 (Navel)	2.8	0.12		2	0B*	<0.01		Chevron 2001 T-326
					0	<0.01	Juice (procedural recovery, 45%)	Sprayed under tree up to drip line
					7	<0.01		
					15	<0.01		
					28	<0.01		
					0	<0.01		
					7	<0.01	Pulp (procedural recovery, 67%)	
					15	<0.01		
					28	<0.01		
CA, USA 1963-66 (Navel) Treatments 1963: 2 1964: 5 1965: 6					0B*	<0.01		T-630
1966	2.24	0.24	935	4	32	0.02, 0.01	Terminals	Terminals sprayed
				(17)	62	<0.01, <0.01	Immature fruit	
						0.01, 0.01	Terminals	
					92	<0.01, <0.01	Terminals	
					132	≤0.01, <0.01	Mature fruit	
1965	1.12	0.12	935	3	30	<0.01, <0.01	Immature fruit	Terminals sprayed
				(10)		<0.01, <0.01	Terminal	
				5	40	≤0.01, <0.01	Mature fruit	
				(12)		<0.01, <0.01	Terminals	
	2.24	0.24	935	3	30	<0.01, <0.01	Immature fruit	
				(10)		0.01, <0.01	Terminals	
				5	40	≤0.01, <0.01	Mature fruit	
				(12)		<0.01, <0.01	Terminals	
1964	1.12	0.12	935	2	46	≤0.01, <0.01	Fruit	Directed spray to the ground around the base of trees
				(2)		<0.01, <0.01	Terminals	
				5	13	≤0.01, <0.01	Fruit	
						<0.01, <0.01	Terminals	

Country, year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
	2.24	0.24	935	2	46	≤0.01, <0.01	Fruit	
				(4)		<0.01, <0.01	Terminals	
				5	13	≤0.01, <0.01	Fruit	
				(7)		<0.01, <0.01	Terminals	
1963	2.24	0.17	935	2	38	≤0.01	Fruit	
CA, USA					0B*	<0.01		T-648
1965	33.6	3.6		1	35	<0.01, <0.01	Immature fruit	Directed spray
(Navel)						<0.01, <0.01	Terminals	to ground
					152	≤0.01, <0.01	Mature fruit	under trees and
						<0.01, <0.01	Terminals	rototiilled in
					346	<0.01, <0.01	Immature fruit	the top of soil
						<0.01, <0.01	Terminals	
CA, USA				1	0B*	<0.01	Spray hit lower	T-758
1965	1.12	0.12	935		3	0.08, 0.06	branches and fruit;	
(Navel)							fruit dropped on sprayed weeds on day 0, 1, 2, and 3; composite samples taken on day 3	
CA, USA					0B*	<0.01		T-936
1965	1.12	0.12	935	5	6	≤0.01, <0.01	Fruit	
(Navel)				(10)				
	2.24	0.24	935	5	6	≤0.01, <0.01	Fruit	
				(12)				
FL, USA					0B*	<0.01		T-631
1964-66								Broadcast
Orange								spray around
(Valencia)								each tree on an
Treatments								area of 100 sq
1964: 4								ft.
1965: 4								
1966	2.24	0.054	2060	1	31	≤0.01, <0.01	Mature fruit	
				(9)		<0.01, <0.01	Juice	
						<0.01, <0.01	Terminals	
					61	<0.01, <0.01	Terminals	
1965	1.12	0.054	2060	1	59	<0.01, <0.01	Immature fruit	
				(5)		0.03, 0.03	Terminals	
				4	177	≤0.01, <0.01	Mature fruit	
							Juice	
	2.24	0.11	2060	1	59	<0.01, <0.01	Fruit	
				(5)			Terminals	
				4	63	≤0.01, <0.01	Terminals	
				(8)				
				4	177	0.06, 0.03	Mature fruit	
						<0.01, <0.01	Juice	
						≤0.01, <0.01		
						<0.01, <0.01		
1964	1.12	0.054	2060	1	58	<0.01, <0.01	Immature fruit	
						0.04, 0.03	Terminals	
	2.24	0.11	2060			<0.01, <0.01	Immature fruit	
						0.02, 0.02	Terminals	
FL, USA, 1965	2.44		2040	1	0B*	<0.01		T-903
(Hamlin)					3	0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	
FL, USA	1.12			1	0B*	<0.05		Ross *et al.*
1972					14	≤0.05	Fruit	1978
(unknown)								AGA No2561
Italy, 1993					0B*	<0.02		Dick *et al.*
(Biondo)	0.80	0.080	1000	1	7	≤0.02	Fruit	1995b
								IT10-93-H348

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
(Navelina)	0.80	0.080	1000	1	0B* 7	<0.02 ≤0.02	Fruit	IT10-93-H349
GRAPEFRUIT								
USA, 1970 Grapefruit (unknown)	1.12	-		1	0B* 3 35	<0.05 ≤0.05 <0.05	Fruit	Anon 1970 Summary only
LEMON								
USA, 1970 (unknown)	1.12			1	0B* 3	<0.05 ≤0.05	Fruit	Anon 1970 Summary only
CA, USA 1972 (unknown)	1.12			1	0B* 49	<0.05 ≤0.05	Fruit	Ross *et al.* 1978
LIME								
FL, USA 1966 (Tahiti)	1.12		1870	5	0B* 1	<0.01 ≤0.01, <0.01	Fruit	Chevron 2001 T-1110

*B: control
Immature fruit 1-5 cm in diameter (size varies from trial to trial)
Numbers in parentheses are the cumulative application number since 1963 in T-630 and T- 936 (higher dose) or since 1964 in T-631 and T-936 (lower dose).

Pome fruits

Paraquat is used to control weeds around the base of pome fruit trees.

Trials were carried out in Canada, Germany and the UK using rates from 1.12 to 4.5 kg ai/ha and even a highly exaggerated rate of 12.3 kg ai/ha. In the last case, paraquat was applied directly to the bark of the tree to simulate worst-case conditions. In some cases, two applications were made, either in the same or subsequent years. Apples were harvested from 0 to 780 days, and pears 0-77 after the last application.

Table 21. Paraquat residues in pome fruits from supervised trials in Canada, Germany and the UK.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
APPLE								
Ontario, Canada, 1962 (Delicious)	2.24		935	1	0B* 14	<0.01 <0.01		Calderbank & Yuen 1963 Cambellville
(Spy)	1.68 1.12		935	1	0B* 14	<0.01 <0.01		Cambellville
(Delicious)	2.24		935	1	0B* 14	<0.01 <0.01		Inglewood
(Spy)	2.24		935	1	0B* 14	<0.01 <0.01		Inglewood
(McIntosh)	2.24 2.80		935	1 1	0B* 6 11	<0.01 <0.01 x 4 <0.01		Guelph
NS, Canada, 1962 (McIntosh)	2.24		374	1	0B* 12	<0.01 <0.01, <0.01		Kentville
BC, Canada, 1962 (Seedlings)	2.24		1871	1	0B* 13	<0.01 <0.01		Summerland

Country, year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
Fernhurst, UK					0B*	<0.01	Sprayed to:	
1962	1.12		935	1	12	<0.01	Base of trees	
(Laxton Superb)	11.2			1	12	<0.01	Base of trees	
				1	12	<0.01	Bark of trees	
	12.32			1	12	<0.01	Bark of trees	
Ontario, Canada,	2.24		5610	1	0B*	<0.01		Kemptville
1961					16	<0.01		
(McIntosh)								
Ontario, Canada,					0B*	<0.01		Calderbank &
1963	2.24		935	1	85	<0.01, <0.01		McKenna 1964
(McIntosh)	4.48			1	85	<0.01, <0.01		Carlisle
	2.24			2	5	<0.01, <0.01		
	4.48			2	5	<0.01, <0.01		
(Winesap)	1.12		234	1	131	<0.01		Guelph
(McIntosh)					0B*	<0.01		Guelph
	1.12		234	1	131	<0.01		
(Delicious)					0B*	<0.01		
	2.24		935	1	5	<0.01		
	4.48					<0.01		
	2.24			1	27	<0.01		
	4.48					<0.01		
	2.24			2	27	<0.01		
	4.48					<0.01		
	2.24			1	122	<0.01		
	4.48					<0.01		
(McIntosh)					0B*	<0.01		Carlisle
	2.24		935	1	20	<0.01		
	4.48				20	<0.01		
	2.24			2	20	<0.01		
	4.48				20	<0.01		
Fernhurst, UK					0B*	<0.01		Second year
1963	0.56		702	2	780	<0.01		treatment
(Laxton Superb)								
Germany					0B*	<0.01		Earl &
1990	1.0		1000	1	0	<0.01	Fruit from tree	Anderson
(Golden					14	<0.01	Fruit from tree	1992a
delicious)						0.19	Fruit on ground	Rs9023B3
(Gloster)					0B*	<0.01		Rs9023B4
	1.0		1000	1	0	<0.01	Fruit from tree	
					14	<0.01	Fruit from tree	
						0.05	Fruit on ground	
(Idared)					0B*	<0.01		Rs9023E1
	1.0		1000	1	0	<0.01	Fruit from tree	
					14	<0.01	Fruit from tree	
						0.03	Fruit on ground	
(Cox orange)					0B*	<0.01		Rs9023G1
	1.0		1000	1	0	<0.01	Fruit from tree	
					14	<0.01	Fruit from tree	
						0.02	Fruit on ground	
PEAR								
Ontario, Canada,					0B*	<0.01		Calderbank &
1963	2.24		935	1	9	<0.01		McKenna 1964
(Clapp)	4.48					<0.01		Winona
	2.24			1	17	<0.01		
	4.48					<0.01		
	2.24			2	17	<0.01		
	4.48					<0.01		
	2.24			1	77	<0.01		
	4.48					<0.01		

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Germany 1990 (Williams Christ)	1.0		1000	1	0B* 0 14	<0.01 <0.01 <0.01 0.06	 Fruit from tree Fruit from tree Fruit on ground	Earl & Anderson 1992a Rs9023E2
(Vereindechant)	1.0		1000	1	0B* 0 14	<0.01 <0.01 <0.01 0.06	 Fruit from tree Fruit from tree Fruit on ground	Rs9023G2

*B: control

Stone fruits

Paraquat is used to control weeds around the base of stone fruit trees.

Residue trials have been carried out on peaches, cherries and plums in Canada, Germany, the UK and the USA. Application rates ranged from 1.0 to 4.5 kg ai/ha applied to the base of the fruit trees up to three times in a season and the fruit were harvested up to 103 days later.

In two special trials on plums in the UK, paraquat was applied directly to the suckers at rates from 0.22 to 1.34 kg ai/ha without leaving detectable residues in the fruits harvested 21 or 55 days later. In the trials in Germany, samples of fruit were placed onto the sprayed herbage on the ground and collected for analysis about one week later.

Table 22. Paraquat residues in stone fruits from supervised trials in Canada, Germany, the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
PEACH								
Ontario, Canada, 1963 (Vedette)	2.24 4.48 2.24 4.48 2.24 4.48		935	1 1 2 2 1 1	0B* 14 14 14 14 87 87	<0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01		Calderbank & McKenna 1964 Hamilton
(Veteran)	1.12		749	2	0B* 44	<0.01 <0.01		
(Elberta)	1.12		749	2	0B* 59	<0.01 <0.01		
Germany 1990 (Red Haven)	1.00		1000	1	0B* 11	<0.01 <0.01 0.04	 Fruit from tree Fruit on ground	Earl & Anderson 1992a Rs9023E3
(Red Haven)	1.00		1000	1	0B* 13	<0.01 <0.01 0.02	 Fruit from tree Fruit on ground	Rs9023E4
PLUM								
Canada, 1963 (Sapa & Dura)	1.12		234	2	0B* 72	<0.01 <0.01		Calderbank & McKenna 1964 Guelph

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Fernhurst, UK 1963 (Coe's golden drop)	0.22 0.45 0.90 1.12 1.34		833	1	0B* 21 55 21 55 21 55 21 55 21 55	<0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01	All applied direct to suckers	Calderbank & McKenna 1964
NY, USA 1977 (unknown)	1.12			1	103	<0.05		Ross *et al.* 1978 AGA No5038
MI, USA, 1977 (unknown)	1.12			1	94	<0.05		AGA No5018
CA, USA, 1987 (French)	4.48	1.93		3	0B* 28	<0.01 <0.05 <0.01 <0.05	Fresh plum Dried prune Fresh plum Dried prune	Roper 1989a 45CA-87-523
(French)	4.48	1.93		3	0B* 28	<0.01 <0.05 <0.01 <0.05	Fresh plums Dried Prunes Fresh plum Dried prune	45CA-87-599
Germany, 1990 (unknown)	1.00		1000	1	0B* 14	<0.01 <0.01 <0.01	Fruit from tree Fruit on ground	Earl & Anderson 1992a Rs9023B2
APRICOT								
BC, Canada, 1964 (unknown)	2.24		935	1	0B* 58	<0.01 <0.01		McKenna 1966
CHERRY								
Canada, 1963 (Montmorency)	2.24 4.48 2.24 4.48 2.24 4.48		935	1 2 1	0B* 9 9 42	<0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01		Calderbank & McKenna 1964
Germany 1990 (Bocca)	1.0		1000	1	0B* 14	<0.01 <0.01 0.07	Fruit from tree Fruit on ground	Earl & Anderson 1992a Rs9023B1
(Hedelfinger)	1.0		1000	1	0B* 12	<0.01 <0.01 0.07	Fruit from tree Fruit on ground	RS9023G4
WA, USA, 1977 Sour cherry (unknown)	1.12			1	63	<0.05		Ross *et al.* 1978 AGA No4745
MI, USA, 1977 Sour cherry (unknown)	1.12			1	25	<0.05		AGA No4685

*B: control

Berries and other small fruits

Paraquat is used to control grass and broad-leaved weeds round grape vines where the chemical is applied between the rows of established vines, usually once or twice during the growing season.

Residue trials have been conducted on grapes in Canada, Japan, Switzerland and the USA at rates between 0.3 and 4.5 kg ai/ha applied once or twice in a season. Grapes were harvested at maturity, from 0 to 196 days after the last application.

In six trials in Germany paraquat was applied between the rows of established vines at a rate of 1.0 kg ai/ha. Grapes were sampled between 10 and 14 days after application. In these trials, bunches of grapes were also placed on the sprayed herbage a few days after application and collected for analysis about 7 days later.

Paraquat is recommended for use on strawberries either as a guarded spray for inter-row weeding or as a post-harvest treatment for the control of suckers. The maximum use rate is 1.1 kg ai/ha applied up to twice in a season. Paraquat was applied to strawberry plants in France, Germany, Ireland and the UK at rates of 0.84 to 1.32 kg ai/ha applied once or twice.

Paraquat is recommended as an inter-row directed spray for cane and bush fruits. Residue trials were conducted in Canada on red and black currants, raspberries, loganberries, blueberries and gooseberries and fruits were harvested 10 to 226 days after application at rates from 0.56 to 2.2 kg ai/ha.

Table 23. Paraquat residues in berries and other small fruits from supervised trials in Canada, France, Germany, Ireland, Japan, Switzerland, the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
GRAPE								
Canada, 1961 (Siebel 6339)	1.1		1300	2	67	≤0.02	Post-emergence inter-row application Treated with bis(methyl sulfate) salt	Edwards 1974
(Siebel 13053)	1.1		1300	2	67	≤0.02		
(Siebel 9249)	1.1		1300	2	67	≤0.02		
(Siebel 10878)	2.2		560	1	84 119	≤0.01 <0.01		
Canada, 1962 (Siebel 6339)	1.1 2.2		270	1	101 102	≤0.01 ≤0.01	Post-emergence inter-row application	Edwards 1974
(Siebel 29186)	1.1		270	1	101	≤0.01		
(President)	2.2		NA	1	80	≤0.01		
Canada, 1963 (Siebel 29186)	0.7 1.9		1500	1 1	122	≤0.01 ≤0.01	Post-emergence directed	Edwards 1974
(Siebel 6339)	1.0 1.9		1500	1 1	122	≤0.01 ≤0.01		
(Concord)	2.2 4.4		1130	1 2 1 2	6 19 122 19 6 19 122 19	≤0.01 <0.01 <0.01 ≤0.01 ≤0.01 <0.01 <0.01 ≤0.01		
Switzerland, 1971 (unknown)	0.3 0.4		1000	1	85 133 196	<0.01 <0.01 <0.01		Edwards 1974
Japan, 1973 (Golden Queen)	0.72		NA	5	7	≤0.01, <0.01		Edwards 1974
(Muscat Bailey A)	0.72		NA	5	1	≤0.01, <0.01		

Country, year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
Germany, 1990 (Riesling)	1.0		1000	1	0B* 0 10	<0.01 <0.01 <0.01 0.13	 From vine From vine From ground	Earl & Anderson 1992b Rs9022E1
(Scheurebe)	1.0		1060	1	0B* 0 14	<0.01 <0.01 <0.01 0.09	 From vine From vine From ground	Rs9022E2
(Portogieser)	1.0		1000	1	0B* 0 14	<0.01 <0.01 <0.01 0.10	 From vine From vine From ground	Rs9022E3
(Weissbur gunder)	1.0		1000	1	0B* 0 14	<0.01 <0.01 <0.01 0.17	 From vine From vine From ground	Rs9022E4
(Bacchus)	1.0		1000	1	0B* 0 14	<0.01 <0.01 <0.01 0.04	 From vine From vine From ground	Rs9022E5
(Morio Muskat)	1.0		1000	1	0B* 0 14	<0.01 <0.01 0.07	 From vine From ground	Rs9022E6
NY, USA, 1977 (unknown)	1.12			1	0B* 135 149	<0.05 <0.05 <0.05		Ross *et al.* 1978 AGA No4953 AGA No5039
CA, USA, 1997 (Thompson Seedless)	5.6		279	1	0B* 0 0 21	<0.01 <0.05 <0.01 <0.01 <0.05	Fresh grape, juice Dried grape Fresh grape Juice Dried grape	Spillner *et al.* 1998 Broadcast 02-CA-97-601
CANE FRUITS								
Ontario, Canada, 1963 Blackcurrant (Saunders Topsy)	2.24		749-935	1	0B* 35	<0.01 <0.01	Post-emergence directed	Calderbank & McKenna 1964
Redcurrant (Cherry Perfection)	2.24		749-935	1	0B* 35	<0.01 <0.01		
Ontario, Canada, 1964 Blackcurrant (Unknown)	2.24		935	1	0B* 42 71	<0.01 <0.01 <0.01	Post-emergence directed	McKenna 1966 Guelph
Ontario, Canada, 1964 Redcurrants (Cherry reflection)	2.24		935	1	0B* 71	<0.01 <0.01	Post-emergence directed	McKenna 1966 Guelph
BC, Canada, 1963 Blueberries (Dixie)	0.84 1.40		899 899	1	0B* 80	<0.01 <0.01 <0.01	Post-emergence directed	Calderbank & McKenna 1964
BC, Canada, 1963 Blueberries (Dixie)	0.84 1.40		899 899	1	85	<0.01 <0.01		
BC, Canada, 1964 Blueberries (Dixie)	0.56 1.12 1.68 2.24		748	1	0B* 65	<0.01 <0.01 <0.01 <0.01 <0.01	Post-emergence directed	McKenna 1966 Pitt Meadows

Country, year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
BC, Canada, 1964 Blueberries (Dixie)	 0.56 1.12 1.68 2.24		 748	 1	0B* 65	<0.01 <0.01 ≤0.01 ≤0.01 ≤0.01	Post-emergence directed	McKenna 1966 Saanich
BC, Canada, 1963 Loganberries (unknown)	 0.56 1.12 2.24		 438 438 438	 1 1 1	0B* 111 111 111	<0.01 <0.01 ≤0.01 ≤0.01, <0.01	Post-emergence directed	Calderbank & McKenna 1964
BC, Canada, 1964 Loganberries (thornless)	2.24		374	1	0B* 10 20 31	<0.01 ≤0.01, <0.01, <0.01 <0.01, <0.01, <0.01 <0.01, <0.01, <0.01	Post-emergence directed	McKenna 1966 Port Coquitlam
Ontario, Canada 1964 Gooseberries (Captivator)	2.24		935	1	0B* 72	<0.01 ≤0.01	Post-emergence directed	McKenna 1966 Guelph
Ontario, Canada, 1963 Raspberry (Viking)	2.24		749	1	0B* 83	<0.01 ≤0.01	Post-emergence directed	Calderbank & McKenna 1964
BC, Canada, 1963 Raspberry (Puyallup)	1.14 2.24		935	1	90 90	≤0.01 ≤0.01, <0.01, <0.01, <0.01		
Ontario, Canada, 1963 Raspberries (Latham)	1.12		234	1	0B* 128	<0.01 ≤0.01		
BC, Canada, 1964 Raspberries (Viking)	2.24		935	1	0B* 34	<0.01 ≤0.01, <0.01	Post-emergence directed	McKenna 1966 Abbotsford
(Comet)	2.24		935	1	0B* 71	<0.01 ≤0.01 For control, Latham variety was analysed		
(Puyallup)	2.24		842	1	0B* 39 95	<0.01 ≤0.01, <0.01, <0.01 <0.01		
STRAWBERRY								
Ireland, 1963 (Cambridge Vigour)	 0.42 0.84		 562 562	 2 2	0B* 210 210	<0.01 <0.01, <0.01 ≤0.01, <0.01	Post-emergence directed	Calderbank & McKenna 1964
Germany 2001 (Hummi silva)	1.0		400	1	0B* 224	<0.01 ≤0.01	In plastic greenhouse For runner control	Devine & Balluff 2002e G01W058R
(Darselec)	1.0		400	1	0B* 226	<0.01 ≤0.01		G01W059R
France, 2001 (Hummi grande)	1.0		400	1	0B* 217	<0.01 ≤0.01		F01W039R
UK, 2000 (Elsanta)	1.32 1.265 1.142		240 230 208	1 1 1	0B* 50 48 47	<0.05 ≤0.05 ≤0.01 ≤0.01		Nagra & Kingdom 2001 TN-00-003 TN-00-004 TN-00-005

*B: control

Olives. Paraquat is used for the control of weeds in olive groves, where it is applied around the base of the trees. Residue trials have been carried out in Greece, Italy, Spain and the USA (California).

In six trials in Spain in 1991/92, olives were harvested from the ground 0, 1 and 7 days after application. In other trials in Spain, mature olives were sprayed directly on the ground with paraquat at rates from 0.36 to 1.3 kg ai/ha. The fruit were collected after 3-17 days. In one trial in Greece, mature olives were directly sprayed with paraquat at a rate of 1.0 kg ai/ha to simulate possible direct spraying of fruit fallen through collection nets during weed control.

In trials in Italy, paraquat was applied at rates up to 1.8 kg ai/ha to the base of trees. Olives were harvested from the ground 7 to 21 days after application. In the trial in California, the USA, paraquat was applied four times at an exaggerated rate (5.6 kg ai/ha; 22.4 kg/ha total) and the fruit were harvested from the trees for processing into oil and cake.

Table 24. Paraquat residues in olives from supervised trials in Spain, Greece, Italy and the USA.

Country, year Olives (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Spain 1991/1992							Fruit taken from ground	Anderson & Earl 1993
(Cornicabra)					0B*	0.17	Whole fruit	ES10-91H008
						<0.02	Oil	
						0.24	Cake	
	0.60		N/A	1	0	5.2	Whole fruit	
					1	10		
					7	6.9		
					0	0.03	Oil	
					1	0.04		
					7	0.04		
					0	7.8	Cake	
					1	15		
					7	10		
(Cornicabra)					0B*	0.08	Whole fruit	ES10-91H108
						<0.02	Oil	
						0.12	Cake	
	0.60		N/A	1	0	6.4	Whole fruit	
					1	6.0		
					7	4.6		
					0	0.06	Oil	
					1	0.04		
					7	0.03		
					0	9.8	Cake	
					1	9.1		
					7	7.1		
(Hojiblanco)					0B*	<0.02	Whole fruit	ES10-91H208
						<0.02	Oil	
						<0.02	Cake	
	0.60		N/A	1	0	0.64	Whole fruit	
					1	1.5		
					7	2.0		
					0	<0.02	Oil	
					1	<0.02		
					7	<0.02		
					0	0.86	Cake	
					1	2.1		
					7	2.8		

Country, year Olives (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	Reference
(Hojiblanco)					0B*	<0.02	Whole fruit	ES10-91H308
						<0.02	Oil	
						<0.02	Cake	
	0.60		N/A	1	0	1.6	Whole fruit	
					1	3.6		
					7	1.6		
					0	<0.02	Oil	
					1	<0.02		
					7	<0.02		
					0	2.1	Cake	
					1	4.9		
					7	2.1		
(Manazel)					0B*	0.03	Whole fruit	ES10-91H408
						<0.02	Oil	
						0.04	Cake	
	0.60		N/A	1	0	6.8	Whole Fruit	
					1	7.6		
					7	4.9		
					0	0.06	Oil	
					1	0.03		
					7	<0.02		
					0	9.3	Cake	
					1	10		
					7	6.8		
(Manazel)					0B*	0.05	Whole fruit	ES10-91H508
						<0.02	Oil	
						0.07	Cake	
	0.60	-	N/A	1	0	9.1	Whole fruit	
					1	8.7		
					7	5.8		
					0	0.03	Oil	
					1	0.02		
					7	<0.02		
					0	13	Cake	
					1	12		
					7	8.1		
Greece 1985 (Tsounati)					B*	<0.005	Olives picked & then directly sprayed Oil	Kennedy 1985 INT H 11.85
	1.0		500	1	5	<0.005		
Italy, 1986 (Coratina)					0B*	<0.05	Fruit picked up from ground	Gatti 1987 60/86/1
	0.54		1000	1	7	<0.05		
					14	<0.05		
					21	<0.05		
	0.89		1000	1	7	<0.05		
					14	<0.05		
					21	<0.05		
	1.79		1000	1	7	<0.05		
					14	<0.05		
					21	<0.05		
Italy, 1993 (Frantioio)							Fruit picked from tree	Dick *et al.* 1995a IT10-93-H338
							Fruit	
	1.56		N/A	1	0B*	<0.10	Oil	
						<0.05	Fruit	
					7	<0.10	Oil	
						<0.05		
Italy, 1993 (Coratina)							Fruit picked from tree	IT10-93-H339
							Fruit	
	1.56		N/A	1	0B*	<0.10	Oil	
						<0.05	Fruit	
					7	<0.10	Oil	
						<0.05		

Country, year Olives (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, USA, 1988 (Manzanilla)							Fruit picked from tree Fruit, Oil, Cake	Roper 1989i 73CA88-526
	5.6		N/A	4	0B* 13	<0.05 <0.05 <0.05 <0.05	Fruit Oil Cake	
Spain, 1987 (Picual)					0B*	<0.05	Analysed fruit were sprayed and picked up from ground	Kennedy 1987 VG-H.1
	0.36		500	1	6 17	0.11 0.08		
	0.60		500		6 17	0.20 0.23		
	0.60		500		6 17	0.57 0.50		
	1.00		500		6 17	0.86 0.63		
Spain, 1986 (Picual)					0B*	<0.02	Sampled from ground	Massey 1987d VG-H.2
	0.36		600	1	7 14	0.40 0.42		
	0.60		600		7 14	0.73 0.74		
	0.60		600		7 14	2.2 2.1		
	1.00		600		7 14	3.9 4.4		
Spain, 1999 (Hojiblanco)					0B*	<0.05	44-58% of analysed olives were on ground at treatment	Jones 2000a ES50-99-S03 3
	1.23		336	1	7	2.1 <0.05 0.77 <0.05	Fruit , unwashed Oil, from unwashed Fruit, washed Oil, from washed	
	1.35		368	1	3	3.4 <0.05 1.3 <0.05	Fruit , unwashed Oil, from unwashed Fruit, washed Oil, from washed	
Spain, 1999 (Arbequina)					0B*	<0.05	17-32% of analysed olives were on ground at treatment	ES50-99-S13 3
	1.08		293	1	3	0.66 <0.05 0.66 <0.05	Fruit , unwashed Oil, from unwashed Fruit, washed Oil, from washed	
	1.18		321	1	7	0.24 <0.05 0.47 <0.05	Fruit , unwashed Oil, from unwashed Fruit, washed Oil, from washed	
Spain 2001 (Hojiblanca)					0B*	<0.05	14-37% of analysed olives were on ground at treatment	Devine *et al.* 2003 ES051-01-S0 13
	1.09		347	1	3	0.45 0.19 0.12 <0.05 <0.05	Whole fruit Unwashed fruit Washed fruit Virgin oil Refined oil	
					7	0.29	Whole fruit	

Country, year Olives (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	Reference
(Arbequina)					0B*	<0.05	Ca 10% of analysed olives were on ground at treatment	ES060-01-S1 13
	1.10		200	1	3	0.10	Whole fruit	
						0.06	Unwashed fruit	
						<0.05	Washed fruit	
						<0.05	Virgin oil	
						<0.05	Refined oil	
	1.05		192		7	0.08	Whole fruit	
(Hojiblanca)					0B*	<0.05	20-30% of analysed olives were on ground at treatment	ES050-01-S2 13
	1.05		383	1	3	0.88	Whole fruit	
	1.32		360		7	1.45		
Spain 2002 (Picual)					0B*	<0.05	58-83% of analysed olives were on ground at treatment	ES052-01-S3 13
	1.09		298	1	3	1.67	Whole fruit	
	1.15		314		7	1.66		

*B: control

Assorted tropical fruits – inedible peel

Paraquat is recommended for use on fruit trees as a directed spray to the soil around the trees.

Residue trials have been carried out on passion fruit in Hawaii, USA, using a single application at 1.12 to 4.48 kg ai/ha. Fruit were harvested from 1 to 28 days after application.

Residue trials have been carried out on kiwifruit in California, USA, using a single application at 0.56 to 2.24 kg ai/ha. Fruit were harvested from 7 to 14 days after the third application.

Residue trials have been carried out on guava in Hawaii, USA, using a single application of paraquat at 1.12 to 4.48 kg ai/ha. Fruit were harvested from 1 to 28 days after application.

Residue trials have been carried out on banana in Honduras, using three applications of paraquat at 1.4 kg ai/ha, or a single application at double this rate. Fruit were harvested from 0 to 90 days after the last application.

Table 25. Paraquat residues in assorted tropical fruits with inedible peel from supervised trials in Honduras and the USA.

Country, year crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	Reference
HI, USA, 1970					0B*	<0.01		Chevron
Passion Fruit	1.12	0.911	123	1	1	≤0.01, 0.13	Whole fruit	1972b
(Yellow Lilikoi)						0.01, 0.01	Edible pulp	WC-98&
						<0.01, 0.21	Peel	WC-127
					4	<0.01, 0.06	Whole fruit	(2 trials)
						0.01, 0.01	Edible pulp	
						<0.01, 0.07	Peel	
					7	0.01, 0.02	Whole fruit	
						<0.01, 0.01	Edible pulp	
						0.02, 0.03	Peel	
					14	<0.01, 0.01	Whole fruit	
						<0.01, 0.01	Edible pulp	
						<0.01, 0.01	Peel	
					28	<0.01, 0.01	Whole fruit	

Country, year crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
						<0.01, 0.02	Edible pulp	
						<0.01, 0.01	Peel	
	2.24	1.82	123	1	1	0.02, 0.08	Whole fruit	
						0.01, 0.02	Edible pulp	
						0.02, 0.11	Peel	
					4	<0.01, 0.10	Whole fruit	
						0.01, 0.06	Edible pulp	
						<0.01, 0.13	Peel	
					7	0.02, 0.02	Whole fruit	
						0.01, 0.02	Edible pulp	
						0.02, 0.03	Peel	
					14	0.01, 0.03	Whole fruit	
						<0.01, 0.02	Edible pulp	
						0.01, 0.03	Peel	
					28	<0.01, 0.02	Whole fruit	
						0.01, 0.04	Edible pulp	
						<0.01, 0.01	Peel	
	4.48	3.64	123	1	1	0.01, 0.19	Whole fruit	
						0.01, 0.01	Edible pulp	
						0.02, 0.29	Peel	
					4	<0.01, 0.02	Whole fruit	
						<0.01, 0.01	Edible pulp	
						<0.01, 0.05	Peel	
					7	0.01, 0.06	Whole fruit	
						0.01, 0.06	Edible pulp	
						0.01, 0.07	Peel	
					14	<0.01, 0.02	Whole fruit	
						<0.01, 0.01	Edible pulp	
						<0.01, 0.03	Peel	
					28	<0.01, 0.02	Whole fruit	
						<0.01, 0.01	Edible pulp	
						<0.01, 0.03	Peel	
CA, USA, 1976					0B*	<0.01		IRP-4 1981
Kiwifruit	0.56		468	3	7	<0.01		
(Hayward)					14	<0.01		
	1.12				7	<0.01		
					14	<0.01		
	2.24				7	<0.01		
					14	<0.01		
HI, USA, 1970					0B*	<0.01		Chevron
Guava	1.12		748	4	1	<0.01	Edible pulp	1972a
(Clonal selections)						<0.01	Peel	Malama-Ki
					4	<0.01	Edible pulp	Farm
						<0.01	Peel	
					7	<0.01	Edible pulp	
						<0.01	Peel	
					14	<0.01	Edible pulp	
						<0.01	Peel	
					28	<0.01	Edible pulp	
						<0.01	Peel	
	2.24		748	4	1	<0.01	Edible pulp	
						<0.01	Peel	
					4	<0.01	Edible pulp	
						<0.01	Peel	
					7	<0.01	Edible pulp	
						<0.01	Peel	
					14	<0.01	Edible pulp	
						<0.01	Peel	
					28	<0.01	Edible pulp	
						<0.01	Peel	
	4.48		748	1	1	<0.01	Edible pulp	
						<0.01	Peel	
					4	<0.01	Edible pulp	

Country, year crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	Reference
						<0.01	Peel	
					7	<0.01	Edible pulp	
						<0.01	Peel	
					14	<0.01	Edible pulp	
						<0.01	Peel	
					28	<0.01	Edible pulp	
						<0.01	Peel	
HI, USA, 1970					0B*	<0.01		Waimanalo
Guava	1.12		748	4	1	<0.01	Edible pulp	Farm
(Beaumont)						<0.01	Peel	
					4	<0.01	Edible pulp	
						<0.01	Peel	
					7	<0.01	Edible pulp	
						<0.01	Peel	
					14	<0.01	Edible pulp	
						<0.01	Peel	
					28	<0.01	Edible pulp	
						<0.01	Peel	
				2	6	<0.01	Frozen canned juice	
				(8)		<0.01	Discarded skin & seed	
							Discarded stone cells	
						<0.01		
	2.24		748	5	1	<0.01	Edible pulp	
						<0.01	Peel	
					4	<0.01	Edible pulp	
						<0.01	Peel	
					7	<0.01	Edible pulp	
						<0.01	Peel	
					14	<0.01	Edible pulp	
						<0.01	Peel	
					28	<0.01	Edible pulp	
						<0.01	Peel	
	4.48		748	1	1	<0.01	Edible pulp	
						<0.01	Peel	
					4	<0.01	Edible pulp	
						<0.01	Peel	
					7	<0.01	Edible pulp	
						<0.01	Peel	
					14	<0.01	Edible pulp	
						<0.01	Peel	
					28	<0.01	Edible pulp	
						<0.01	Peel	
				2	6	<0.01	Frozen canned juice	
				(8)		<0.01	Discarded skin & seed	
						<0.01	Discarded stone cells	
Honduras, 1964					0B*	<0.01		McKenna
Bananas	1.40		584	3	0	<0.01 x4	Fruit flesh	1966
(Valery)						0.01, <0.01 x3	Peel	
					3	<0.01 x4	Fruit flesh	
						<0.01 x4	Peel	
					7	<0.01	Fruit flesh	
						<0.01	Peel	
						<0.01 x3	Whole fruit	
					14	<0.01 x4	Whole fruit	
					21	<0.01 x4	Whole fruit	
					45	<0.01 x4	Whole fruit	
					90	<0.01 x4	Whole fruit	
	2.80			1	0	0.66	Peel	
						<0.01	Fruit flesh	
						0.12, 0.01,	Whole fruit	
						<0.01 x2		
					3	<0.01 x4	Whole fruit	
					7	<0.01 x4	Whole fruit	

Country, year crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
					14	<0.01 x4	Whole fruit	
					23	<0.01 x4	Whole fruit	
					44	<0.01 x4	Whole fruit	
					90	<0.01 x4	Whole fruit	

*B: control
Number in ( ): application number from previous year.

Bulb vegetables

Residue trials have been conducted on onions in Canada, Germany and the UK.

In trials in Canada, paraquat was sprayed at a rate of 1.12 kg ai/ha for pre-emergence, or 2.2 kg ai/ha for inter-row application.

Supervised residue trials were carried out on onions in Germany using paraquat for inter-row weed control. In 1983 paraquat was applied twice or four times at rates of 1.0 to 2.1 kg ai/ha and the onions harvested from 0 to 21 days after the last application. In 1984 onions were harvested 0 to 21 days after one or three applications of 1.0 to 1.3 kg ai/ha. In a German trial in 1965 paraquat was applied at 1.79 kg ai/ha as a harvest aid.

Table 26. Paraquat residues in onions from supervised trials in Canada, Germany and the UK.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Manitoba, Canada, 1962					0B*	<0.01		Calderbank & Yuen 1963
(Autumn Spice)								
(Brigham Yellow	1.12		187	1	143	<0.01		
Globe)	1.12		187	1	143	<0.01		
Canada, 1964					0B*	<0.01		Edwards 1974
(Unknown)	2.20		1120	1	36	<0.01		Ref No. 4148
Germany, 1965					0B*	<0.01	Harvest aid	McKenna
	1.79		303	1	20	0.30	Peeled	1966
						0.14	Unpeeled	
UK, 1964					0B*	<0.01		McKenna
Spring (Unknown)	1.68		N/A	1	126	0.02	Pre-sowing	1966
	1.68		N/A	1+			Pre-sowing &	
	2.24		N/A	3	21	<0.01	inter-row	
Germany, 1983					0B*	<0.01		Swaine 1983a
(Weibe Königin)	1.0		1000	2	0	<0.01	Post-emergence	RS8378 B4
					5	0.02	directed application	
					9	0.01		
					14	0.02		
					21	<0.01		
(Stuttgarter					0B*	<0.05		RS8378 E2
Riesen)	2.1		2100	1+				
	1.6		1600	1	0	0.02		
					3	<0.01		
					8	<0.01		
					12	<0.01		
					16	<0.01		

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
(Jumbo)					0B*	<0.02		RS8378 E3
	1.56		1560	1+				
	0.9		900	1+				
	1.25		1250	1+				
	1.05		1050	1	0	0.01		
					4	<0.01		
					8	0.01		
					12	<0.01		
					16	<0.01		
					21	<0.01		
Germany, 1984 (Stuttgarter Riesen)					B*	<0.01	Post-emergence directed application	Massey 1987a
	1.3		1300	1	0	0.01		RS8423E3
					3	<0.01		
					8	<0.01		
					14	<0.01		
					21	<0.01		
	0.9		3000	1	0	<0.01		RS8427E2
					3	<0.01		
					8	<0.01		
					14	<0.01		
					21	<0.01		
(Jumbo)					B*	<0.01		RS8423B3
	1.0		1000	3	0	<0.01		
					4	<0.01		
					9	<0.01		
					14	<0.01		
					21	<0.01		
	0.75		2500	3	0	<0.01		RS8427B4
					4	<0.01		
					9	<0.01		
					14	<0.01		
					21	<0.01		
						<0.01		

*B: control

Brassica vegetables

Paraquat is recommended for use in the cultivation of Brassica vegetables either during seed bed preparation as a pre-plant or pre-emergence treatment, or applied as a post-emergence directed or guarded spray for inter-row weed control.

Residue trials have been carried out on a number of Brassica crops, including cabbage in Canada, Japan, Spain and the USA; broccoli in Canada; Brussels sprouts in The Netherlands; and cauliflower in Canada. In trials in Canada, Spain and the USA, paraquat was applied once or twice at 0.56 to 2.24 kg ai/ha for inter-row weed control and the crop harvested 5 to 52 days after the last application.

In trials on cabbage in Japan, paraquat was applied three times at 0.96 kg ai/ha or once at a highly exaggerated rate (19.2 kg ai/ha). The crop was harvested 5 days after the last of the three applications or 52 days after the high rate application.

The trials on Brussels sprouts in The Netherlands involved a harvest aid application directly to the sprouts.

Table 27. Paraquat residues in Brassica vegetables from supervised trials in Canada, Japan, Netherlands, Spain and the USA.

Country, year Brassica (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Ontario, Canada, 1964 Broccoli (Unknown)	2.2			1	0B* 36	<0.01 ≤0.01		McKenna 1966
Japan, 1973 Cabbage (Taibyo Ace)	 0.96 19.2			 3 1	0B* 5 52	<0.03 ≤0.03, <0.03 <0.03, <0.03		Edwards 1974
Japan, 1973 Cabbage (Wase Syuho)	 0.96 19.2			 3 1	0B* 5 52	<0.03 ≤0.03, <0.03 <0.03, <0.03		
Spain, 1998 Cabbage (Savoy Prince)	1.0		197	1	0B* 15	<0.05 <0.05	Post-emergence directed	Coombe & Gallardo 1999 ES10-98-SH0 15
Spain, 1998 Cabbage (Savoy King)	1.0		290	1	0B* 16	<0.05 <0.05		ES10-98-SH1 15
Ontario, Canada, 1964 Cabbage (Copenhagen bald)	2.2			1	0B* 51	<0.01 0.06		McKenna 1966
FL, USA, 1989 Chinese cabbage (Joi choy)	1.05 pre 0.56 1.05 pre 0.56		280	1+ 3 1+ 3	0B* 21 21	<0.05 <0.05, <0.05, <0.05, <0.05 <0.05, <0.05, 0.06, 0.07	1 pre & 3 post-emergence directed applications	Choban 1991
Ontario, Canada, 1964 Cauliflower (unknown)	2.2			1	0B* 45	<0.01 ≤0.01		McKenna 1966
Netherlands, 1965 Brussel spout (Unknown)	1.2			1	0B* 31 31	<0.01 1.6 7.3	Harvest aid Peeled spouts Unpeeled sprouts	McKenna 1966

*B: control

Fruiting vegetables

Paraquat is recommended for use in the cultivation of fruiting vegetables, either during seed bed preparation as a pre-plant or pre-emergence treatment, or applied as a post-emergence directed or guarded spray for inter-row weed control.

Numerous residue trials have been carried out on cucumbers, melons and summer squash in the USA, on tomatoes in Canada and the USA, and on peppers in Canada and the USA.

In residue trials on cucumbers, melons and squash in California, USA, paraquat was applied at 1.12 kg ai/ha pre-emergence followed by three inter-row applications at 0.56 kg ai/ha.

The trials in Canada on tomatoes were for pre-emergence (or pre-planting) weed control in which paraquat was used at a low rate (0.11 kg ai/ha) in combination with residual herbicides. The trials on tomatoes in the USA were generally with post-emergence directed application at 0.56 to 2.24 kg/ha, but also involved an exaggerated single high rate (11.2 kg ai/ha) pre-emergence or applications of 1.12

kg ai/ha followed by three inter-row directed applications at 2.8 kg ai/ha (the last for a processing study).

The trials on peppers were for inter-row weed control using paraquat at 0.56 to 2.24 kg ai/ha.

Table 28. Paraquat residues in fruiting vegetables, other than cucurbits, from supervised trials in Canada and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
TOMATO								
USA					0B*	<0.01	Post-emergence directed application	Chevron 1975c
FL, 1974 (Walter)	0.56		412	1	0	<0.01, 0.02		T-2866
					7	0.01, 0.02		
					14	<0.01, 0.02		
					21	0.03, 0.04		
TX, 1974 (Homestead 24)	0.56		514	3	0	<0.01, <0.01		T-2867
					7	<0.01, 0.02		
					14	<0.01, 0.02		
					21	<0.01, <0.01		
	1.12		514	3	0	<0.01, <0.01		
					7	<0.01, <0.01		
					14	<0.01, <0.01		
					21			
FL, 1975 (Walter)	0.56		359	1	0	<0.01		T-2872
					7	<0.01		
					14	<0.01		
					21	<0.01		
	1.12		359	1	0	<0.01		
					7	<0.01		
					14	0.01		
					21	<0.01		
FL, 1975 (Walter)	0.56		421	1	0	<0.01, <0.01		T-2875
					7	<0.01, <0.01		
					14	<0.01, <0.01		
					21	<0.01, <0.01		
	1.12		421	1	0	<0.01, <0.01		
					7	<0.01, <0.01		
					14	<0.01, <0.01		
					21	<0.01, <0.01		
LA, 1975 (Creole)	0.56		187	5	0	0.02, 0.02		T-2877
					7	0.01, 0.02		
					14	<0.01, 0.01		
					21	<0.01, <0.01		
	1.12		187	5	0	<0.01, 0.02		
					7	<0.01, 0.01		
					14	<0.01, <0.01		
					21	<0.01, <0.01		
Fl, 1974 (Walter)	0.56		421	1	0	<0.01, <0.01		T-3148
					7	<0.01, <0.01		
					12	<0.01, <0.01		
					21	<0.01, <0.01		
	1.12		421	1	0	<0.01, <0.01		
					7	<0.01, <0.01		
					12	<0.01, <0.01		
					21	<0.01, <0.01		
MD, 1975 (Campbell 28)	1.12 pre		374	1+				T-3333
	1.12		299	4	7	0.02		
					14	0.01		
					21	0.02		
	1.12 pre		374	1+				
	2.24		299	4	7	0.02		
					14	0.02		
					21	0.07		

Country, year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	References
CA, USA, 1988 (Jack Pot)							1 pre+3 post-emergence directed applications	Roper 1989q 18CA88-789
					B*	<0.005	Unwashed tomato	
						<0.005	Juice	
						<0.025	Catsup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
	1.12pre			1+				
	2.8			3	30	≤0.005	Unwashed tomato	
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
(Jack Pot)					B*	<0.005	Unwashed tomato	18CA88-790
						<0.005	Juice	
						<0.025	Catsup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
	1.12pre			1+				
	2.8			3	30	≤0.005	Unwashed tomato	
						<0.005	Juice	
						<0.025	Catsup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
Ontario, Canada, 1963 (Heinz 1350)					0B*	<0.01	Post-emergence directed application	Calderbank McKenna 1964
	0.11		1348	1	69	<0.01		
	0.22		1122		69	<0.01		
(Heinz 1350)	0.11		1122	1	0B*	<0.01		
					71	<0.01, <0.01, <0.01		
FL, USA 1987 (Unknown)	11.2			1	0B*	<0.01	Pre-emergence application	Roper 1989h 75FL-87-517 E
					76	≤0.01		
CA, USA 1987 (Unknown)	11.2			1	0B*	<0.01		45CA-87-518
					87	≤0.01		
PEPPERS								
USA FL, 1975 Sweet pepper (Early Cal Wonder)					0B*	<0.01	Post-emergence directed application	Chevron 1975c T-2868
	0.56		421	1	0	<0.01, <0.01		
					7	<0.01, <0.01		
					12	<0.01, <0.01		
					21	<0.01, <0.01		
	1.12		421	1	0	<0.01, <0.01		
					7	<0.01, <0.01		
					12	<0.01, <0.01		
					21	<0.01, <0.01		
TX, 1974 Sweet pepper (Yolo Wonder 34)	0.56		514	3	0	<0.01, <0.01		T-2869
					7	<0.01, <0.01		
					12	<0.01, <0.01		
					21	0.01, 0.01		
	1.12		514	3	0	0.01, 0.03		
					7	<0.01, <0.01		
					12	<0.01, <0.01		
					21	<0.01, 0.02		

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
FL, 1974	0.56		421	1	0	<0.01, <0.01		T-2873
Sweet pepper					7	<0.01, <0.01		
(Early Cal					12	<0.01, <0.01		
Wonder)					21	<0.01, <0.01		
	1.12		421	1	0	<0.01, <0.01		
					7	<0.01, <0.01		
					12	<0.01, <0.01		
					21	<0.01, <0.01		
LA, 1975	0.56		187	4	0	<0.01, <0.01		T-3152
Sweet pepper					7	<0.01, <0.01		
(Keystone Giant					14	<0.01, <0.01		
Resistant)					21	<0.01, <0.01		
	1.12		187	4	0	<0.01, <0.01		
					7	<0.01, <0.01		
					14	<0.01, <0.01		
					21	<0.01, <0.01		
MD, 1975	1.12pre		374	1+				T-3332
Sweet pepper	1.12		299	4	7	<0.01		
(Yolo Wonder)					12	<0.01		
					21	0.03		
	1.12pre		374	1+				
	2.24		299	4	7	<0.01		
					12	0.03		
					21	<0.01		
Canada, 1964	2.2		1120	1	0B*	<0.01	Post-emergence	Edwards 1974
Pepper					27	<0.01	directed application	Ref No 3778
(California								
Wonder)								

*B: control

Table 29. Paraquat residues in fruiting vegetables, cucurbits, from supervised trials in the USA.

Country, year Cucurbits (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CUCUMBER								
CA, USA, 1988					0B*	<0.025	1 pre + 3 post directed	Roper 1989e
(Unknown)	1.12 pre			1+			application	19CA-88-428
	0.56			3	31	<0.025		
CA, USA, 1988					0B*	<0.025		19CA-88-429
(Unknown)	1.12 pre			1+				
	0.56			3	23	<0.025		
CA, USA, 1988					0B*	<0.025		18CA-88-430
(Unknown)	1.12 pre			1+				
	0.56			3	8	<0.025		
CA, USA, 1988					0B*	<0.025		18CA-88-431
(Unknown)	1.12 pre			1+				
	0.56			3	8	<0.025		
MELON								
CA, USA, 1988					0B*	<0.025	1 pre + 3 post directed	Roper 1989e
Melons	1.12 pre			1+			application	19CA-88-432
(Unknown)	0.56			3	52	<0.025		
CA, USA, 1988					0B*	<0.025		19CA-88-433
Melons	1.12 pre			1+				
(Unknown)	0.56			3	52	<0.025		
CA, USA, 1988					0B*	<0.025		17CA-88-434
Melons	1.12 pre			1+				
(Unknown)	0.56			3	62	<0.025		
CA, USA, 1988					0B*	<0.025		17CA-88-435
Melons	1.12 pre			1+				
(Unknown)	0.56			3	62	<0.025		
SUMMER SQUASH								

Country, year Cucurbits (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, USA, 1988 Summer Squash (Unknown)	1.12 pre 0.56			1+ 3	0B* 8	<0.025 <0.025	1 pre + 3 post directed application	Roper 1989e 18CA-88-436
CA, USA, 1988 Summer Squash (Unknown)	1.12 pre 0.56			1+ 3	0B* 8	<0.025 <0.025		18CA-88-437
CA, USA, 1988 Summer Squash (Unknown)	1.12 pre 0.56			1+ 3	0B* 8	<0.025 <0.025		18CA-88-438
CA, USA, 1988 Summer Squash (Unknown)	1.12 pre 0.56			1+ 3	0B* 33	<0.025 <0.025		17CA-88-439

*B: control

Leafy vegetables

Paraquat is recommended for use in the cultivation of leafy vegetables either during seed bed preparation as a pre-plant or pre-emergence treatment, or applied as a post-emergence directed or guarded spray for inter-row weed control.

Residue trials on lettuce have been carried out in Canada, Germany, Spain, the UK and the USA at rates of 0.42 to 2.24 kg/ha, and lettuce was sampled 0 to 147 days after application. In most of these trials, the whole lettuce head was analysed without removal of the outer wrapper leaves.

Residue trials on kale have been carried out in France, Italy and the UK at rates of 1.0 to 2.24 kg/ha, and kale was sampled 0 to 147 days after application. In trials in France and Italy, the residue levels of paraquat immediately after spray drying (0 days) represent a worst-case situation.

Six trials on turnip greens were carried out in the USA at a rate of 1.12 kg/ha pre-emergence and tops were sampled 55 to 128 days after application.

Table 30. Paraquat residues in leafy vegetables from supervised trials in Canada, France, Germany, Italy, Spain, the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
LETTUCE								
Ontario, Canada, 1964 (Mixed)	2.24 2.24 1.12 2.24 1.12 0.49 0.97		935 935 935 935 935 468 468	1 1 1 1 1 1 1	0B* 36 55 55 55 55 71 71	<0.01 <0.01 0.08 0.05 0.05 0.04 0.01 0.01		McKenna 1966 Pre-emergence
UK, 1965 (Unknown)	0.841 0.841 0.841		N/A N/A N/A	1 1 1	0B* 39 58 72	<0.01 <0.01 0.01 <0.01 0.02 <0.01 <0.01 <0.01	Head, unwashed Head, washed Head, unwashed Head, washed Head, unwashed Head, washed Head, unwashed Head, washed	
UK, 1964 (Unknown)	1.68 pre 2.24		N/A N/A	1+ 2	0B* 46	<0.01 0.02, 0.03	 Head	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
FL, USA, 1978 Crisphead (Minetto)	0.42 0.84		449 449	1 1	41 41	<0.01 <0.01	Mature head, trimmed Mature head, trimmed	Florida Dep. of Agri. 1978 Post-emergence directed T-4574
FL, USA, 1978 Crisphead (Minetto)	0.42 0.84		449 449	1 1	56 56	<0.01 <0.01	Head, trimmed Head, trimmed	T-4575
FL, USA, 1978 Butter lettuce (Green Boston)	0.56		655	1	24	0.02	Head, trimmed	T-4576
FL, USA, 1978 Romaine lettuce (Volmaine)	0.56		655	1	18	<0.01	Head, trimmed	T-4577
FL, USA, 1978 Leaf lettuce (Florida Deep Heart)	0.56		468	1	69	<0.01	Bunch, trimmed	T-4578
FL, USA, 1978 Romaine lettuce (Paris Island Los)	0.56		561	1	32	<0.01	Heads, trimmed	T-4580
FL, USA, 1978 Crisphead (Great Lakes)	0.56		561	1	49	<0.01	Heads, trimmed	T-4581
Germany, 1983 (Unknown)	 1.00 0	 0.100	 1000	 2	0B* 0 4 9 14 21	<0.01 0.39 0.40 0.01 0.02 <0.01		Swaine 1983c Rs8378B1
Germany, 1983 (Unknown)	1.00	0.100	1000	2	0 4 9 14 21	0.35 0.21 0.04 0.04 <0.01		Rs8378B2
Germany, 1983 (Unknown)	1.80 pre 1.60		1800 1600	1+ 1	0 3 6 9 14	0.06 0.09 0.22 0.13 0.06		Rs8378B3
Germany, 1983 (Capitan)	 0.75 0.75		 1250 2500	 1+ 1	B* 0 4 9 14 21	0.02 0.48 0.05 0.02 0.02 <0.02	 Head	Kennedy 1984b RS8372B1
(Meridian)	 0.75 0.75		 1250 2500	 1+ 1	B* 0 4 9 14 21	0.02 0.10 0.05 <0.02 <0.02 <0.02	 Head	RS8372B2
Endive (Solera)	 0.69 0.84		 2300 1400	 1+ 1	B* 0 3 7 10	0.02 <0.02 <0.02 0.02 0.02	 Head	RS8372E1

Country, year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
Germany, 1984					0B*	0.01	Post-emergence directed	Massey 1987c RS8423E1
(Eichblatt)	1.30		1300	1	0	1.4	Heads	
					3	0.25		
					7	0.16		
					12	0.10		
					16	0.03		
Endive	1.25		1250	1	0	0.56	Heads	RS8423E2
					4	0.33		
					7	0.26		
					14	0.39		
					21	0.20		
(Capitan)					B*	0.01	Heads	RS8423B1
	1.00		1000	2	0	0.01		
					4	0.01		
					10	<0.01		
					14	<0.01		
					21	<0.01		
(Eichblatt)					B*	<0.01	Heads	RS8427E1
	0.96		1600	1	0	1.3		
					3	0.44		
					7	0.16		
					12	0.06		
					16	0.04		
(Capitan)					B*	0.01	Heads	RS8427B1
	0.75		1000	2	0	<0.01		
					4	0.01		
					10	<0.01		
					14	<0.01		
					21	<0.01		
(Astra)					B*	0.01	Heads	RS8427B3
	0.75		2500	2	0	0.01		
					4	0.01		
					9	0.01		
					14	<0.01		
					21	0.01		
NY, USA, 1986 (Montello)					0B*	<0.02	Post-emergence directed	Massey 1987e 34NY86-014 R
	1.12		N/A	1	31	<0.02, <0.02, <0.02		
			N/A	1	31	<0.02, <0.02, <0.02		
(Green Lake)					0B*	<0.02		34NY86-015 R
	0.56		N/A	1	31	<0.02, <0.02, <0.02		
Spain, 1999 (Verna)	0.60	0.200	300	1	0	0.01		Jones 2000d AF/4716/ZE/1 Andalucia
(Odra)	0.60	0.200	300	1	0	<0.01		AF/4716/ZE/2 Andalucia
KALE								
UK, 1964					0B*	<0.01		McKenna 1966
Kale	1.68 pre			1+				
(Unknown)	2.24			1	113	0.04		
	2.24			1	72	0.03		
	1.12 pre		31	1	147	0.02		
	2.24 pre		31	1	147	0.02		
France, 1998 (Winterbor)					0B*	<0.05	Post-emergence directed; sampled after spray dried	Jones & Cowley 1999 AF/4148/CE/1
	0.97		291	1	0	0.07		

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Italy, 1998 (Cavolonero di Firenze)	1.02		307	1	0 0	0.16		AF/4148/CE/2
TURNIP GREENS								
USA, 1988 AL (7-top)	1.12			1	0B* 128	<0.025 <0.025	Pre-emergence	Roper 1989p 44AL-88-410
GA (Purple top)	1.12			1	97	<0.025		45GA-88-411
CA (Purple top)	1.12			1	55	0.03		18CA-88-413
FL (Purple top)	1.12			1	70	0.05		42FL-88-414
TN (Purple top)	1.12			1	66	0.04		43TN-88-415
TX (Purple top)	1.12			1	62	<0.025		12TX-88-416

*B: control

Legume vegetables and pulses

Paraquat is recommended as a pre-emergence or post-emergence directed inter-row treatment for legume vegetables and pulses, and for use as a harvest aid desiccant for soya beans.

Residue trials have been carried out on beans (except soya beans) in Canada, Germany, Spain, Italy, and The Netherlands using paraquat for pre-emergence weed control at single applications of 0.56 or 2.24 kg ai/ha or post-emergence directed inter-row weeding at rates from 0.28 to 1.12 kg ai/ha.

Residue trials have been carried out on peas in Canada and the UK using paraquat for pre-emergence weed control as single applications or post-emergence directed inter-row weeding at rates from 0.14 to 1.68 kg ai/ha, with harvest 55 to 152 days after application.

Paraquat was applied at 0.20 or 1.12 kg ai/ha to peas as a harvest aid desiccant in Australian and US trials with samples taken 1 to 38 days after application.

Several trials on soya beans were conducted in Brazil from 1981 to 1983 with a harvest aid desiccation application of paraquat at 0.25 to 0.80 kg/ha with sampling 2 to 21 days after application.

US trials involved a pre-emergence application with or without a post-emergence directed application from 0.14 to 1.4 kg/ha, or 5 applications of paraquat (3.3 kg/ha total) followed by a harvest aid desiccation at 0.7 kg/ha with sampling of seeds 1 to 17 days after the last application, or a harvest aid desiccation of 0.28 or 0.56 kg/ha with sampling after 6 to 36 days.

Table 30. Paraquat residues in legume vegetables and pulses from supervised trials in Australia, Brazil, Canada, Germany, Italy, Netherlands, Spain, the UK and the USA.

Country, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
PHASEOLUS								
Italy, 1999 Beans with pods (Masai)	0.66		300	1	0B* 0	<0.01 0.04 0.01	Post-emergence directed Plants without pods Pods	Jones 2000b AF/4714/ZE/1
Spain, 2001 Dried field beans (Pinet)	1.0		300	1	0B* 0	<0.05 <0.05 7.6	Post-emergence directed Dried field bean Straw	Devine & Balluff 2002d S01W033R

Country, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Germany, 2001 Dried field beans (Optimus)	1.0		400	1	0B* 0	<0.05 <0.05 2.6	Post-emergence directed Dried field bean Straw	Devine & Balluff 2002c G01W056R
Germany, 2001 Beans with pods (Maja)	1.0		400	1	0B* 0 3 7	<0.05 <0.05 1.4 0.10 0.34 <0.05 0.91	Post-emergence directed Beans with pods Straw Beans with pods Straw Beans with pods Straw	Devine & Balluff 2002b G01W054R
Spain, 2001 Beans with pods (Cleo)	1.0		400	1	0B* 0 3 7	<0.05 0.09 0.41 <0.05 0.09 <0.05 0.15	Post-emergence directed Beans with pods Straw Beans with pods Straw Beans with pods Straw	Devine & Balluff 2002a S01W031R
The Netherlands 2002 Beans with pods (Valance)	1.0		300	1	0B* 7	<0.05 <0.05 0.08	Post-emergence directed Beans with pods Straw	Devine & Poppezijn 2003 CEMS-1839/01
Spain, 2002 Beans with pods (Moncayo)	1.0		200	1	0B* 7	<0.05 <0.05 0.21	Post-emergence directed Beans with pods Straw	Devine & Orellana 2003a AF/6396/SY/1
Ontario, Canada, 1963 Beans (Small white) (Small white) (Michelite)	 0.56 0.56 1.12		 281 281 225	 1 1 1	0B* 122 123 105	<0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01 <0.01	Pre-emergence Seed Pod Stalk Seed Pod Stalk Seed Pod Stalk	Calderbank & McKenna 1964

Country, year Crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
Ontario, Canada, 1963 Beans (Small white)					0B*	<0.01	Post-emergence directed	Calderbank & McKenna 1964 Edwards 1974
							Seed	
	0.28		281	1	107	<0.01	Pods	
						<0.01	Stalk	
						<0.01	Seed	
					119	<0.01	Pods	
						<0.01	Stalk	
						<0.01	Seed	
	0.56		281	1	55	<0.01	Seed	
					68	<0.01	Seed	
	1.12		281	1	72	<0.01	Stalk	
						<0.01	Seed	
	0.56		561	1	71	<0.01	Pods	
						<0.01	Stalk	
						<0.01	Seed	
	0.56		NA	1	68	<0.01	Pods	
						<0.01	Stalk	
					86	<0.01	Seed	
	1.12		NA	1	68	<0.01	Pods	
						<0.01	Stalk	
					86	<0.01	Seed	
	0.28		281	1	101	<0.01	Podd	
						<0.01	Stalk	
						<0.01	Seed	
					118	<0.01	Pods	
						<0.01	Stalk	
						<0.01		
Ontario, Canada, 1964 Beans (Small white)	1.12		468	1	0B* 60	<0.01 <0.01	Pre-emergence Seed	McKenna 1966
VICIA								
UK, 1964 Broad beans (unknown)	1.68pre 2.24		N/A N/A	1+ 1	0B*	<0.01	Pre+post-emergence	McKenna 1966
					71	<0.01	Seed	
						<0.01	Pod	
					85	<0.01	Seed	
						0.01	Pod	
Spain, 2000 Broad beans (Reina Mora)	0.69		314	1	0B*	<0.01	Post-emergence directed Seed	Jones 2000c AF/4715/ZE/1
					0	<0.01	Pod	
						<0.01		
Spain, 2002 Fresh broad bean (Muchamiel)	1.0		200	1	0B*	<0.05	Post-emergence directed Fresh broad bean	Devine & Orellana 2003b AF/6397/SY/1
					0	<0.05	Straw with empty pods	
						1.5		
PEAS								
Ontario, Canada, 1963 (Lincoln)	0.56		38	1	0B* 123	<0.01 <0.01	Pre-emergence Vines	Calderbank & McKenna 1964

Country, year Crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
Ontario, Canada,					0B*	<0.05	Post-emergence directed	Calderbank &
1963							Seed	McKenna 1964
(Lincoln)	1.12		281	1	72	<0.01	Seed	
	0.56		281	1	68	<0.01	Seed	
	0.56		281	1	55	<0.01	Seed	
(Dark green	0.28		270	1	70	<0.01	Seed	
perfection)	0.14		270	1	70	<0.01	Seed	
(Lincoln)	0.56		561	1	71	<0.01	Pods	
					71	<0.01	Stalk	
					71	<0.01	Seed	
(unknown)	0.56		N/A	1	68	<0.01	Stalk	
					68	<0.01	Seed	
	0.56		N/A	1	68	<0.01	Stalk	
					68	<0.01	Vines	
(Lincoln)	0.28		281	1	119	<0.01		
UK, 1964	1.68		N/A	1	0B*	<0.01	Pre-emergence	McKenna 1966
Peas					152	<0.01 <0.01	Seed	
(Unknown)						<0.01 <0.01	Pod	
Australia, 1992					0B*	<0.05	Post-emergence harvest	Markus 1993a
Field peas							aid	AU10-93-H206
(Alma)	0.20		70	1	15	0.09	Seed	
						12	Whole plant	
					25	0.31	Seed	
						12	Whole plant	
	0.40		70	1	15	0.10	Seed	
						21	Whole plant	
					25	0.50	Seed	
						15	Whole plant	
Australia, 1993					0B*	<0.05	Post-emergence harvest	Brown 1994b
Field peas							aid	AU10-93-E204
(Dunn)	0.20		70	1	1	0.11	Seed	
						9.1	Straw	
					7	0.36	Seed	
						12	Straw	
					14	0.39	Seed	
						9.6	Straw	
					21	0.41	Seed	
						6.4	Straw	
	0.40		70	1	14	0.54	Seed	
						18	Straw	
					21	0.51	Seed	
						16	Straw	
ID, USA					0B*	<0.05	Post-emergence harvest	Lurvey 1997
1993							aid	93-ID04
Dry Pea	0.56		240	1	7	0.16, 0.18,		
(Columbian)						0.20, 0.25		
	1.12		240	1	7	0.10, 0.11,		
						0.14, 0.17		
WA, USA					0B*	<0.05	Post-emergence harvest	93-WA32
1993							aid	
Dry Pea	0.56		193	1	7	<0.05, 0.10,		
(D.S. perfection)						0.13, 0.15		
	1.12		193	1	7	0.09, 0.12,		
						0.12, 0.16,		
CHICK PEA								
Australia, 1992	0.20		70	1	0B*	<0.05	Post-emergence harvest	Markus 1993b
Chick Peas							aid	MAP-GRA-92
(Amethyst)					38	0.23	Grain	
						1.0	Straw	
	0.40		70		38	0.44	Grain	
						4.0	Straw	

Country, year Crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
Australia, 1993 Chick Peas (Desi)	0.20		70	1	0B*	<0.05	Post-emergence harvest aid	Brown 1994a AU10-94-H105
					16	0.05	Seed	
						1.4	Straw	
					22	<0.05	Seed	
						2.0	Straw	
	0.40		70	1	16	0.21	Seed	
						4.1	Straw	
					22	0.19	Seed	
						3.1	Straw	
SOYA BEANS								
Brazil, 1981 (UFV1)					0B*	<0.05	Harvest aid	Hayward & Robbins 1981a
	0.40		300	1	8	≤0.05	Beans	
					9	<0.05		
					10	<0.05		
					12	<0.05		
(Davis)	0.40			1	4	≤0.05	Beans	
(unknown)	0.80			1	4	<0.05	Beans	
(IAC4)	0.40			1	5	0.16	Beans	
(Parana)	0.40			1	10	0.08	Beans	
(Boussler)	0.40			1	8	0.28	Beans	
(Davis)	0.40			1	5	0.11	Beans	
Brazil, 1982 (Various)					0B*	<0.05	Harvest aid	Kennedy & Robbins 1982
	0.40		100	1	4	0.34	Beans	
			100		6	0.09		
			178		7	0.10		
			170		8	0.11		
			170		7	0.07		
			170		9	0.13		
Brazil, 1983 (Various)					0B*	<0.02	Harvest aid	Kennedy *et al.* 1983
	0.30		250	1	3	0.08	Beans	
			30	1	11	0.02		
	0.32		80	1	2	<0.02		
			200	1	5	<0.02		
			80	1	8	0.05		
	0.40		125	1	3	0.16		
			125	1	3	0.18		
			250	1	3	0.43		
			55	1	4	0.21		
			125	1	5	0.16		
			250	1	5	0.28		
			250	1	5	0.28		
			125	1	6	0.08		
			350	1	6	0.03		
			250	1	9	0.03		
			340	1	9	≤0.02		
			25	1	11	0.02		
			250	1	11	0.02		
			250	1	15	0.14		
			350	1	16	0.06		
			300	1	17	0.07		
			350	1	18	0.03		
			330	1	20	<0.02		
			330	1	21	<0.02		

Country, year Crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
Brazil, 1986 (Various)					0B*	<0.05	Harvest aid (+diquat) Beans	Earl & Muir 1988 88JH402
	0.25		300	1	7	<0.05		
					7	<0.05		
					7	<0.05		
					7	<0.05		
					7	<0.05		
					8	<0.05		
					9	<0.05		
					9	<0.05		
					11	<0.05		
					13	<0.05		
MS, USA, 1992 (Asgrow 5979)					0B*	<0.05	Post-emergence harvest aid	Roper 1993l
	1.4		187	1	13	<0.05	Beans	
						<0.05	Unscreened beans	
						0.52	Dust, <2540 µm	
USA, 1987					OB*	<0.025	Pre-emergence, post-emergence directed	Roper 1989m
NE (Asgrow 3127)	1.1 pre 0.14 post			1+ 2	52	<0.025	Forage	92NB-87-560
					63	<0.025	Hay or fodder	
					88	<0.025	Seed	
IL (William 82)	1.1 pre 0.14 post			1+ 2	59	<0.025	Forage	US04-87-561
					59	<0.025	Hay or fodder	
					90	<0.025	Seed	
IA (Pioneer 9271)	1.1 pre 0.14 post			1+ 2	37	<0.025	Forage	A1IA-87-562
					84	0.2	Hay or fodder	
					84	0.03	Seed	
LA (Yield King 613)	1.1 pre 0.14 post			1+ 2	19	0.05	Forage	36LA-87-563
					48	0.1	Hay or fodder	
					63	<0.025	Seed	
MS (Centennial)	1.1 pre 0.14 post			1+ 2	65	<0.025	Forage	US05-87-564
					79	0.05	Hay or fodder	
					79	<0.025	Seed	
MO (Asgrow 3544)	1.1 pre 0.14 post			1+ 2	53	<0.025	Forage	48MO-87-565
					102	<0.025	Hay or fodder	
					102	<0.025	Seed	
AR (DPL 504)	1.1 pre 0.14 post			1+ 2	74	<0.025	Forage	06AR-87-566
					41	<0.025	Hay or fodder	
					109	<0.025	Seed	
AL (Braxton)	1.1 pre 0.14 post			1+ 2	70	<0.025	Forage	62AL-87-567
					138	<0.025	Hay or fodder	
					138	<0.025	Seed	
GA (Kirby)	1.1 pre 0.14 post			1+ 2	34	<0.025	Forage	83GA-87-568
					79	0.04	Hay or fodder	
					79	<0.025	Seed	
De (Pioneer 9441)	1.1 pre 0.14 post			1+ 2	3	1.8	Forage	44DE-87-569
					30	0.3	Hay or fodder	
					30	<0.025	Seed	

Country, year Crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
USA, 1997					0B*	<0.05	Pre-emergence; two post-emergence directed; one spot; one desiccation application	Spillner *et al.* 1999
	1.40 pre			1+				
	0.56 post			2+				
	0.05 spot			1+				
NC(Hyperformer	0.70 des			1	3	0.06	Seed	01-NC-97-610
574)					7	<0.05		50-TN-97-611
TN(Hutachson)					3	<0.05		49-AR-97-612
AR(AG5901)					3	0.09		69-LA-97-613
LA(Delta Pine					3	<0.05		63-IA-97-615
DP3478)					3	0.11		63-IA-97-616
IA(Pella)					3	0.05		63-IA-97-617
IA(D260)					1	0.07		04-IL-97-618
IA(L2233)					2	0.07		
IL(Asgrow A3237)					6	<0.05		
					11	0.07		
					15	0.05		
					3	0.06		60-IL-97-619
					3	<0.05		60-IL-97-620
IL(Asgrow 4401)					3	<0.05		67-IN-97-621
IL(Asgrow 2704					3	0.07		67-IN-97-622
STS)					3	<0.05		37-KS-97-623
IN(Pioneer 9342)					3	0.06		36-MN-97-624
IN(Alder 373)					3	<0.05		37-MO-97-625
KS(Ciba 373)					3	0.06		68-NE-97-626
MN(ICI D162)					3	<0.05		89-OH-97-627
MO(Ciba 3362)					3	<0.05		34-SD-97-628
NE(Pioneer 9281)					3	<0.05		79-WI-97-629
OH(Asgrow 3701)					1	0.25		05-MS-97-631
SD(Garst D210)					3	0.69		
WI(Asgrow					7	0.20		
XP19505)					11	0.16		
MS(Asgrow 5979)					17	0.16		
USA (unknown)					0B*	<0.01	Harvest aid desiccation	Chevron 1985
IA, 1975	0.28		327	1	15	<0.01, 0.03	Bean	T-3402A
LA, 1977	0.56		47	1	10	0.18, 0.23	Bean	T-3996
LA, 1977	0.28		47	1	10	0.11, 0.05 0.12, 0.23	Bean Hull	T-4145
GA, 1977	0.28		37	1	14	0.08 0.67	Bean Hull	T-4147
IA, 1977	0.28		28	1	19	0.04, 0.03 0.07, 0.08	Bean Hull	T-4191
IA, 1977	0.28		28	1	27	<0.01, <0.01 <0.01, <0.01	Bean Hull	T-4192
IL, 1977	0.28		28	1	22	0.03, 0.01 0.12, 0.08	Bean Hull	T-4193
IL, 1877	0.28		28	1	16	0.02, 0.02 0.05, 0.05	Bean Hull	T-4194
NE, 1978	0.28		47	1	14	0.05, 0.06	Bean	T-4716
IA, 1978	0.28		28	1	17	0.02, 0.01	Bean	T-4717
IL, 1978	0.28		47	1	7	0.02, 0.03	Bean	T-4729
IL, 1978	0.28		28	1	15	0.01, 0.02	Bean	T-4730
FL, 1978	0.28		28	1	11	≤0.01, <0.01	Bean	T-4767
DE, 1978	0.28		47	1	8	0.15, 0.09	Bean	T-4811
DE, 1978	0.28		47	1	11	0.10, 0.10	Bean	T-4812

Country, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
DE, 1978	0.28		47	1	36	0.12, 0.12	Bean	T-4813
GA, 1978	0.28		47	1	10	<0.01	Bean	T-4818
DE, 1978	0.56		280	1	19	<0.01, 0.03	Bean	T-4858
VA, 1979	0.28		47	1	16	0.07, 0.03	Bean Hull	T-4859
VA, 1979	0.28		47	1	17	0.03, 0.05 0.25, 0.28	Bean Hull	T-4860
OH, 1979	0.28		47	1	6	0.09, 0.07 0.36	Bean Hull	T-4861
OH, 1979	0.28		47	1	7	0.07, 0.08 0.34	Bean Hull	T-4862
IA, 1979	0.28		47	1	10	0.08, 0.07 0.43, 0.31	Bean Hull	T-4949
NE, 1979	0.28		47	1	8	0.07, 0.09 0.50, 0.34	Bean Hull	T-4950
GA, 1979	0.28		47	1	12	<0.01, <0.01	Bean	T-5001
SC, 1979	0.28		47	1	17	<0.01, 0.02	Bean	T-5002
SC, 1979	0.28		47	1	31	<0.01, <0.01	Bean Hull	T-5003
TX, 1979	0.28		47	1	6	0.05, 0.03	Bean	T-5007
IN, 1979	0.28		47	1	6	0.06, 0.08 0.36	Bean Hull	T-5011
IN, 1979	0.28		47	1	7	0.03, 0.05	Bean	T-5012
IN, 1979	0.28		47	1	8	0.04, 0.03	Bean	T-5013
TN, 1979	0.28		252	1	12 19	0.04, 0.04 0.08, 0.07	Bean	T-5014
MS, 1979	0.28		47	1	15	0.04, 0.04	Bean	T-5015
MS, 1979	0.28		47	1	6	0.01, 0.02	Bean	T-5016
FL, 1979	0.28		280	1	13 15	0.02, 0.03 0.03, 0.02	Bean	T-5017
VA, 1979	0.28		47	1	11	0.09, 0.13 0.47, 0.63	Bean Hull	T-5022
VA, 1979	0.28		47	1	28	0.05, 0.07 0.53, 0.56	Bean Hull	T-5023
IL, 1980	0.28		187	1	6 12 14	0.03, 0.02 0.04, 0.06 0.09, 0.08	Bean	T-5218
USA, 1988					B*	 <0.05 <2 <0.05	Harvest aid Forage Hay Seed	Roper 1989n
IL (Fayette)	2.24		38	1	0 5 10 15 21	20 26 24 22 0.1	Hay Forage Forage Forage Seed	22IL-88-458 Ground application
IA (Pioneer 9271)	2.24		38	1	0 5 10 15	24 45 8 9 9 0.05	Forage Hay Forage Forage Forage Seed	36IA-88-459 Ground application
					B*	<25 <15 <0.05	Forage Hay Seed	

Country, year Crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes and references	
IN (Dekalb CX324)	2.24		38	1	0	78	Forage	23IN-88-460
					5	49	Forage	Ground
						70	Hay	application
					10	58	Forage	
					15	45	Forage	
						<0.05	Seed	
MS (DPL 506)	2.24		38	1	0	70	Forage	48MS-88-461
						124	Hay	Ground
					5	49	Forage	application
					10	88	Forage	
					15	73	Forage	
						0.05	Seed	
MO (Williams)	2.24		38	1	0	49	Forage	40MO-88-462
						29	Hay	Ground
					5	51	Forage	application
					11	54	Forage	
					15	43	Forage	
					20	0.1	Seed	
MN (Evans)	2.24		38	1	0	30	Forage	33MN-88-463
						16	Hay	Ground
					5	40	Forage	application
					10	29	Forage	
					15	24	Forage	
						0.1	Seed	
OH (unknown)	2.24		38	1	0	135	Forage	27OH-88-464
						140	Hay	Ground
					5	221	Forage	application
					10	125	Forage	
					15	161	Forage	
					36	2	Seed	
					B*	<0.05	Forage	
						<2	Hay	
						<0.05	Seed	
IL (Pioneer 9271)	2.24		38	1	0	20	Hay	22IL-88-536
					5	26	Forage	Aerial
					10	24	Forage	application
					15	22	Forage	
					21	0.1	Seed	
IA (Sieben SS-235)	2.24		38	1	0	0.12	Forage	36IA-88-537
						80	Hay	Aerial
					5	10	Forage	application
					10	15	Forage	
					15	9	Forage	
						0.2	Seed	
IN (Century)	2.24		38	1	0	29	Forage	24IN-88-538
					5	26	Forage	Aerial
						23	Hay	application
					10	25	Forage	
					15	13	Forage	
					25	<0.05	Seed	
MS (DPL 506)	2.24		38	1	1	38	Forage	48MS-88-539
						31	Hay	Aerial
					5	27	Forage	application
					10	47	Forage	
					15	33	Forage	
					15	0.2	Seed	
MO (Williams 82)	2.24		38	1	0	19	Forage	37MO-88-540
						38	Hay	Aerial
					5	10	Forage	application
					10	10	Forage	
					15	<5	Forage	
					19	0.1	Seed	

Country, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
MN (BSR 101)	2.24		38	1	0	59	Forage	30MN-88-541
						2	Hay	Aerial
					5	23	Forage	application
					10	23	Forage	
					15	22	Forage	
					22	0.08	Seed	
					B*	<1	Forage	
						<2	Hay	
						<0.05	Seed	
OH (Asgrow 3427)	2.24		38	1	0	15	Forage	27OH-88-542
						6	Hay	Aerial
					5	19	Forage	application
					10	8	Forage	
					15	1	Forage	
						0.08	Seed	

B*=control

Root and tuber vegetables

Residue trials were carried out on beetroot in Canada and the UK using paraquat pre-sowing or pre-emergence at 1.12 or 1.7 kg ai/ha, followed (in the UK) with two applications directed inter-row at 2.2 kg ai/ha after crop emergence. Beetroots were harvested 84 to 112 days after the last application.

Similar trials were conducted on sugar beet in the UK with pre-sowing followed by inter-row weed control at rates up to 2.2 kg ai/ha. Beets were harvested 94 to 125 days after the last application. In seven trials in four different States of the USA, a single pre-emergence application was given to sugar beet at 1.12 kg ai/ha and, in one case, at 5.6 kg ai/ha. The crop was harvested 136 to 178 days after application.

Residue trials on carrots, using paraquat for pre-emergence or inter-row weed control, have been carried out in Canada, Germany, the UK and Japan. In one Japanese trial, a highly exaggerated rate of 19.2 kg ai/ha was used. In Germany in 1983 two applications were made to carrots for inter-row weed control at rates from 0.85 to 1.35 kg ai/ha with sampling of roots from 0 to 21 days after the second application, and in further trials in the same year paraquat was applied twice at 0.75 kg ai/ha, or at 0.71 and 0.98 kg ai/ha with roots harvested at intervals up to 22 days after the last application. In trials in Germany in 1984 paraquat was applied from one to three times with harvest after 0-22 days. In trials in Canada and the UK paraquat was applied 1-3 times for inter-row weed control at rates of 0.28 to 2.24 kg ai/ha.

Other residue trials were carried out on parsnips (UK), swedes (UK) and turnips (UK and Canada) using paraquat for pre-emergence weed control (Canada) or pre-emergence followed by inter-row weed control (UK). Rates of application were 0.56 to 2.24 kg ai/ha. In one trial in France on black salsify paraquat was applied as an inter-row treatment at 0.5 and 0.8 kg ai/ha. Salsify roots were harvested 8 and 30 days after treatment.

On potatoes paraquat is recommended for pre-emergence and early post-emergence directed for early and seed potatoes up to 10% emergence; directed for potatoes up to 40% emergence; or for harvest aid desiccation.

In a series of trials in Germany during 1990 paraquat was applied to six different varieties of potatoes, at BBA growth stage 11, for control of grasses and broadleaved weeds, at a rate of 0.40 kg ai/ha. Samples of potato tubers were harvested 59 to 131 days after application.

In trials in the UK in 1963 and 1965 paraquat was applied to potatoes as a post-emergence harvest aid at a rate of 0.56 to 6.72 kg ai/ha and sampled 14 to 41 days post application.

In several residue trials in Canada during 1963 and 1964 paraquat was applied for weed control by pre-emergence, post-crop emergence, or as a harvest aid at 0.20 to 1.12 kg ai/ha. Tubers were harvested 68 to 119 days after application.

In several residue trials in the USA during 1963, 1966, and 1988 paraquat was applied for weed control by pre-emergence, post-emergence directed, and/or harvest aid desiccation at 1.12 to 2.8 kg ai/ha. Tubers were harvested 45 to 83 days after application.

Table 32. Paraquat residues in root and tuber vegetables from supervised trials in Canada, France, Germany, Japan, the UK and the USA.

Country, year crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
BEET & SUGAR BEET								
Ontario, Canada, 1963 Beetroot (Detroit dark red)	 0.56 1.12		 539 539	1	0B* 86 82 86	<0.01 <0.01 <0.01 <0.01	pre-emergence Root	Calderbank & McKenna 1964
UK, 1964 Beetroot (unknown)	1.68 pre 2.24 direct		N/A	1+ 2	112	<0.01 0.01	Root Tops	McKenna 1966
UK, 1964 Sugar beet (Klein)	1.68 pre 2.24 direct 1.68 pre 2.24 direct		N/A N/A	2+ 1 2+ 1	72 84	0.01 0.08 <0.01 0.06	Root Tops Root Tops	McKenna 1966
UK, 1967 Sugar beet (Klein E)	 0.26 0.50 1.10 1.10		 340 340 340 340	 1+ 2 2 2	0B* 96 94 125	<0.01 <0.01, <0.01, <0.01 0.02, 0.02, <0.01, 0.03 0.02, 0.03, 0.02, <0.01	Pre-emergence	Edwards 1974 Ref No 3635, 3636, 3637 Ref No 3411, 3412, 3418, 3419 Ref No 3653, 3654, 3655, 3656
ID, USA, 1988 Sugar Beet (HH-32(Holly))	5.6		N/A	1	0B* 137	<0.05, <0.025 <0.05 <0.05 <0.05 <0.025 <0.05 <0.05 <0.025	 Unwashed Root Unwashed Root** Washed Root** Wet pulp Dry pulp Molasses Sugar	Roper 1989c 16ID88-599
USA, 1988 Sugar Beet (unknown)	1.12		N/A	1	0B* 136 138 151 152 160 178 	<0.025 ≤0.05 <0.025 ≤0.05 <0.025 ≤0.05 <0.025 ≤0.05 <0.025 ≤0.05 <0.025 ≤0.05 <0.025	Pre-emergence Root Top Root Top Root Top Root Top Root Top Root Top	Roper 1989c 33MN88-405 33ND88-406 17CA88-403 34ND88-407 16ID88-404 73CA88-402

Country, year crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CARROT								
NB, Canada, 1963					0B*	<0.01	pre-emergence	Calderbank &
(Gold Pak)	0.28		674	1	104	<0.01	Root	McKenna 1964
						<0.01	Tops	
	0.56		674		104	<0.01	Root	
						<0.01	Tops	
UK, 1963					0B	<0.01	Harvest aid	Calderbank &
(unknown)	0.56		1210	1	26	0.03	Root	McKenna 1964
	0.84		1210	1	26	0.08		
Ontario, Canada, 1964					0B*	<0.01	Root	McKenna 1966
(Long Hyperator)	2.24		935	1	36	<0.01		
UK, 1964					0B*	<0.01	Pre-sowing	McKenna 1966
(unknown)	1.68			1	144	0.02	Root	
						0.14	Tops	
	1.68 pre			1+			Pre-emergence & inter-row	
	2.24			2	63	0.02	Root	
	direct					0.22	Tops	
Japan, 1973					0B*	<0.03		Edwards 1974
(Karuda Gosun)	0.96		N/A	2	113	<0.03		
				3	5	<0.03		
				3	5	<0.03		
	19.2		N/A	1	11	<0.03		
					140	<0.03		
Germany, 1983	1.00		1000	2	0B*	<0.01	Post-emergence	Swaine 1983b
					4	<0.01	Root	RS8378B2
(Caramba)					9	<0.01		
					14	<0.01		
					22	<0.01		
(Elfie)	0.85		850	1+				RS8378E4
	0.95		950	1	0	0.14	Root	
					4	<0.01		
					9	<0.01		
					14	<0.01		
					21	<0.01		
(Karotan)	1.35		1350	1+				RS8378E5
	1.10		1000	1	0	0.02	Root	
					3	0.02		
					7	<0.01		
					11	<0.01		
					15	0.01		
Germany, 1983					0B*	<0.02		Kennedy 1984b
	0.98		3250	1+	0	<0.02		RS8372E4
(Nantaise)	0.71		2350	1	4	<0.02		
					9	0.02		
					14	<0.02		
					21	<0.02		
(Caramba)	0.75		2500	1+	0	<0.02		RS8372B3
	0.75		1250	1	4	<0.02		
					9	<0.02		
					14	<0.02		
					22	<0.02		
(Caramba)	0.75		2500	1+	0	<0.02		RS8372B4
	0.75		1250	1	4	<0.02		
					9	<0.02		
					14	<0.02		
					22	<0.02		

Country, year crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	References
Germany, 1984								
(Lange Rote)	0.75		2500	3	0	<0.01		RS8427B5
					4	<0.01		
					9	<0.01		
					14	<0.01		
(Tip-top)	0.75		1200	1	0	<0.01		RS8427E4
					4	0.01		
					8	<0.01		
					13	<0.01		
					19	0.01		
Germany, 1984	1.00		1000	1	0	0.01		Massey 1987b
					4	0.02		RS8423E5
(Tip-top)					8	0.01		
					13	0.03		
					19	0.01		
(Minota)				2	4	<0.01		RS8423B2
					10	<0.01		
					14	<0.01		
					22	<0.01		
(Nantaise)				3	0	0.01		RS8423B4
					4	0.01		
					9	<0.01		
					14	<0.01		
					21	<0.01		
POTATO								
Germany, 1990 (Hansa)	0.40		400	1	0B*	<0.01	Post-emergence directed	Earl & Anderson 1991
					71	<0.01	Tuber	Rs9024B1
					93	<0.01		
Germany, 1990 (Cilena)	0.40		400	1	0B*	<0.01	Post-emergence directed	Earl & Anderson 1991
					76	<0.01	Tuber	Rs9024B2
					100	<0.01		
Germany, 1990 (Hela)	0.40		400	1	0B*	<0.01	Post-emergence directed	Earl & Anderson 1991
					59	<0.01	Tuber	Rs9024B3
					77	<0.01		
Germany, 1990 (Rebecca)	0.40		400	1	0B*	<0.01	Post-emergence directed	Earl & Anderson 1991
					71	<0.01	Tuber	Rs9024G1
					131	<0.01		
Germany, 1990 (Agria)	0.40		400	1	0B*	<0.01	Post-emergence directed	Earl & Anderson 1991
					73	<0.01	Tuber	Rs9024G2
					115	<0.01		
Germany, 1990 (Nicola)	0.40		400	1	0B*	<0.01	Post-emergence directed	Earl & Anderson 1991
					74	<0.01	Tuber	Rs9024G3
Ontario, Canada, 1963 (Sebago)					0B*	<0.01	Pre-emergence Tuber	Calderbank & McKenna 1964
	0.56		281	1	122	<0.01		
	0.56		281	1	123	<0.01		
	1.12		281	1	100	<0.01		
	1.12		281	1	101	<0.01		
	1.12		281	1	108	<0.01		

Country, year crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Ontario, Canada, 1963					0B*	<0.01	Early post-emergence directed Tuber	Calderbank & McKenna 1964
(Sebago)	0.28		281	1	101	<0.01		
					118	<0.01		
	0.28		281	1	107	<0.01		
					119	<0.01		
(unknown)	0.56		281	1	68	0.02		
(Sebago)	0.56		281	1	79	<0.01		
					98	<0.01		
	0.56		281	1	92	<0.01		
					104	<0.01		
(unknown)	1.12		281	1	86	<0.01		
(Majestic)	1.12		281	1	90	<0.01, <0.01		
Canada, 1963 (Netted Gem)					0B*	<0.01	Harvest aid	Calderbank & McKenna 1964
NB	0.20		674	1	28	<0.01	Tuber	
BC	0.28		1123	1	20	<0.01		
NB	0.40		674	1	28	<0.01		
BC	0.56		1123	1	20	<0.01		
PEI (Green Mountain)	0.28		1348	1	28	<0.01		
	0.56		1348	1	28	0.07		
	0.84		1348	1	28	0.06		
Ontario (Katahdin)	0.28		1123	1	16	0.02, 0.04		
	0.56		1123	1	16	0.04, 0.04		
	0.84		1123	1	16	0.03, 0.04		
BC (Kennebec)	0.28		1123	1	20	0.02		
	0.56		1123	1	20	0.02		
UK, 1963					0B*	<0.01	Harvest aid	Calderbank & McKenna 1964
(King Edward)	1.12		1123	1	14	0.06, 0.07, 0.09, 0.09, 0.10, 0.10, 0.10, 0.13, 0.14, 0.20		
(Majestic)	0.56		225	1	27	0.02, 0.05		
					34	0.04, 0.04		
					41	0.03, 0.03, 0.03, 0.04		
	1.12		225	1	27	0.03, 0.04		
					34	0.02, 0.06		
					41	0.03, 0.04, 0.05, 0.05		
(Cobbler)	0.56		449	1	23	0.02, 0.04, 0.07		
	0.84		449	1	23	0.03, 0.07		
(Warba)	0.56		449	1	23	0.04, 0.04		
	0.84		449	1	23	0.04, 0.05, 0.05, 0.06		
(King Edward)	0.56		225	1	40	0.06, 0.06		
	1.12		225	1	40	0.06, 0.06, 0.08		

Country, year crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	References
Ontario, Canada, 1964					0B*	<0.01	Early post-emergence directed	McKenna 1966
(Kennebec)	0.56		234	1	110	<0.01		
	1.12		234	1	108	<0.01		
(Norland)	0.28		75.8	1	84	<0.01		
	0.56		75.8	1	84	<0.01		
	0.56		75.8	1	98	<0.01		
(Sebago)	0.56		234	1	117	<0.01		
	1.12		234	1	106	<0.01		
Ontario, Canada, 1964							Harvest aid	McKenna 1966
(Netted Gem)	2.24			1	30	0.03		
	4.48			1	30	0.04		
	0.42			1	30	0.05		
(Norland)	0.42		468	1	22	<0.01		
(Katahdin)	0.42		468	1	14	0.02		
(Kennebec)	0.42		468	1	14	0.02		
(Sebago)	0.42		468	1	12	0.11		
UK, 1965 (Maris Peer)					0B*	<0.01	Harvest aid	McKenna 1966
	0.84		562	1	31	0.04, 0.06, 0.04, 0.08, 0.04, 0.06		
	1.68		562	1	31	0.05, 0.04, 0.07, 0.04, 0.08, 0.14, 0.04, 0.07		
	3.36		562	1	31	0.07, 0.07, 0.07, 0.09, 0.04, 0.06		
	6.73		562	1	31	0.09, 0.06, 0.10, 0.09, 0.08, 0.05, 0.10, 0.08		
USA, 1963					0B*	<0.01	Pre-emergence	Chevron 1967
NJ (Green Mountain)	1.12		468	1	45	<0.01	Tuber	T-387
					95	<0.01		
FL (unknown)	1.12		468	1	52	<0.01		T-388
					72	<0.01		
USA, 1966					0B*	<0.01	Early post-emergence	
NJ (Katahdin)	1.12		321	1	83	<0.01	Tuber	T-1193
NJ (Katahdin)	1.12		277	1	82	<0.01		T-1194
NJ (Katahdin)							Post-emergence	Chevron 1967
	1.12		321-331	2	56	0.01	Tuber	T-1195
	1.12		277-331	2	62	0.01		T-1196
NJ (Katahdin)	1.12		321-556	2+1	3	0.01	Post-emergence; then harvest aid Tuber	T-1197
	1.12		277-556	2+1	3	0.02		T-1198
CA (CA long white)	1.12		468	2+1	3	0.04		T-1174
ID, USA, 1988 (Russet Burbank)					0B*	<0.05	Harvest aid Unwashed tuber	Roper 1989b 16ID88-400
						<0.025	Washed tuber	
	2.8			1	7	<0.05	Unwashed tuber from field	
						<0.05	Unwashed tuber from processor	
						0.05	Washed tuber from processor	

Country, year crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	References
ME, USA, 1988 (Superior)					0B*	<0.05	Harvest aid Unwashed tuber	Roper 1989b 56ME88-401
						<0.05	Washed tuber	
	2.8		N/A	1	7	0.11	Unwashed tuber from field	
						0.22	Unwashed tuber from processor	
						0.10	Washed tuber from processor	
OTHER ROOT AND TUBER VEGETABLES								
Ontario, Canada, 1963 Turnip (Laurentian)					0B*	<0.01	pre-emergence	Calderbank & McKenna 1964 (Winona)
	0.56		281	1	122	<0.01	Root	
	1.12		281	1	101	<0.01		
	1.12		281	1	108	<0.01		(Arthur)
Ontario, Canada, 1963 Turnip (Laurentian)					0B*	<0.01	post-emergence	Calderbank & McKenna 1964 (Winona)
	0.56		281	1	80	<0.01	Root	
					97	<0.01		
	0.56		281		92	<0.01		(Arthur)
					104	<0.01		
UK, 1964 Turnips (unknown)	1.68 pre		N/A	1+	64	<0.01	Roots	McKenna 1966
	2.24 direct			1		0.02	Tops	
	1.68 pre		N/A	1+	49	<0.01	Roots	
	2.24 direct			2		0.03	Tops	
UK, 1964 Parsnips (unknown)	1.68 pre		N/A	1+	116	<0.01	Pre-sowing+ inter-row Root	McKenna 1966
	2.24 direct			1		0.18	Tops	
UK, 1964 Swedes (Wilhelmsburger)	1.68 pre		N/A	2+	54	0.01	Root	McKenna 1966
	2.24 direct			2		0.10	Tops	
	1.68 pre		N/A	2+	72	0.01	Root	
	2.24 direct			1		0.04	Tops	
France, 1988 Scorzonere/ BlackSalsify (Benstar)					0B*	<0.02		Benet 1989 FR 10/88H
	0.50		300	1	8	<0.02	Root	
					30	<0.02		
	0.80		300	1	8	<0.02		
					30	<0.02		

*B: control
** from processor

Stalk and stem vegetables

Paraquat is recommended as a pre-emergence or post-emergence directed inter-row treatment for stem vegetables.

Residue trials have been carried out on asparagus, celery, and globe artichokes in Canada and the USA using paraquat for post-emergence directed inter-row weeding with single applications of 1.12 to 3.25 kg ai/ha to asparagus and celery, and three applications of 1.12 or 1.34 kg/ha to artichokes.

Table 33. Paraquat residues in stalk and stem vegetables from supervised trials in Canada and the USA.

Country, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Ontario, Canada, 1963 Asparagus (Waltham)	1.12		281	1	0B* 103	<0.05 <0.05 <0.05	Pre-emergence directed Stalk Fern	Calderbank & McKenna 1964
Ontario, Canada, 1964 Asparagus (Waltham)	1.12		234	1	0B* 70	<0.02 <0.02	Pre-emergence	Chevron 1970 T-1403
USA, 1969 Asparagus MI (California 711) CA (U-72) CA (U-72)	 1.12 2.24 3.25		 337 1870 1870	 1 1 1	0B* 25 8 8	<0.02 <0.02, <0.02 <0.02, 0.02 <0.03, <0.03	Pre-emergence	Chevron 1970 T-1839 T-1838 T-1837
Ontario, Canada, 1964 Celery (Mixed)	2.24		935	1	0B* 36	<0.05 <0.05	Post-emergence Stalk	McKenna 1966
CA, USA 1992 Globe Artichoke (unknown)	 1.12 1.35		 187 627	 3 3	0B* 1 1	<0.05 <0.05 <0.05	Post-emergence directed	Lurvey 1996 92:CA:126 92:CA:125

*B: control

Cereals

Maize. Paraquat is recommended for use in the cultivation of maize during pre-plant or pre-emergence treatment, post-emergence directed or guarded spray for inter-row weed control, or as a harvest aid desiccation.

Two residue trials were conducted on maize in Italy in 1993 in which paraquat was applied at a rate of 0.92 kg ai/ha to the seed bed one day before sowing. Maize silage and cobs were sampled 104 and 136 days after treatment respectively.

Residue trials were carried out in Canada in 1963 on pre-emergence weed control using a rate of 1.12 kg ai/ha, with harvest after 101 to 107 days, and post-emergence at 0.28-1.12 kg ai/ha (harvest 68-122 days). In the following year, similar trials on post-emergence weed control were at 0.56 to 2.2 kg ai/ha. Cobs were harvested 25 to 63 days after application.

A trial was carried out in the UK in 1964 with two pre-sowing applications of 1.7 kg ai/ha followed by a similar directed application of 2.2 kg ai/ha after crop emergence. Maize grain was harvested 84 days after the last application.

Several trials were conducted over several years in several locations in the USA. In 1987 paraquat was applied as a pre-emergence spray at 1.12 kg/ha followed by two post-emergence directed spays at 0.31 kg/ha and sampled after 28 to 95 days. In 1998 one or two post-emergence sprays were used at 0.56 kg ai/ha. In 1972-74 paraquat was applied as a harvest aid desiccation at rates of 0.56 to 1.12 kg/ha and sampled 3 to 27 days after application. Residue levels of paraquat in fodder, cob, grain, oil, and other processed fractions were measured.

Table 34. Paraquat residues in maize from supervised trials in Canada, Italy, South Africa, the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Italy, 1993					0B*	<0.05	Pre-emergence	Anderson & Lant 1994
(Pioneer 3471)	0.92		521	1	104	<0.05	Silage	IT10-93-H385
					136	<0.05	Cob	
(Pioneer 3471)	0.92		483	1	104	<0.05	Silage	IT10-93-H386
					136	<0.05	Cob	
Canada, 1963					0B*	<0.01		Calderbank & McKenna 1964
							Pre-emergence	
Ontario (Golden glow)	1.02		281	1	101	<0.01	Seed	
						<0.01	Straw	
Ontario (Gloden glow)	1.12		281	1	107	<0.01	Seed	
						<0.01	Straw	
Ontario (Golden glow)							Post-emergence	
	0.56		561	1	71	<0.01	Seed	
	0.56		281	1	96	<0.01	Seed	
						<0.01	Straw	
Ontario (Golden glow)	0.56		281	1	97	<0.01	Seed	
						<0.01	Straw	
	0.56		281	1	92	<0.01	Seed	
						<0.01	Straw	
Manitoba (unknown)	0.56		-	1	68	<0.01	Seed	
	1.12				86	<0.01	Seed	
Ontario (Warwick 605)	0.28		562	1	122	<0.01	Seed	
	0.70		562	1	122	<0.01	Seed	
	1.12		562	1	122	<0.01	Seed	
France (INRA260)							Harvest aid	
	0.30		39	1	15	0.18	Grain	
	0.49		39	1	15	0.23	Grain	
Canada, 1964					0B*	<0.01	Post-emergence directed	McKenna 1966
(unknown)	1.12		468	1	60	<0.01	Cob	
						0.01, 0.02	Stalk	
	0.56		477	1	49	0.02	Cob	
	1.12		477	1	49	0.13	Cob	
Ontario (unknown)	1.4		935	1	25	<0.02	Cob	
						1.0	Stalk	
	1.4		1870	1	25	<0.01	Cob	
	1.4		935	1	25	0.23	Stalk	
	2.2		935	1	63	<0.01	Cob	
						<0.01	Stalk	
South Africa, 1965 (unknown)	0.28		93.5	1	60	0.04	Seed	
	0.56		93.5	1	60	0.08	Seed	
UK, 1964					0B*	<0.01	Pre-emergence followed by post-emergence directed	McKenna 1966
(Sweet corn)	1.68 pre			2+				
	2.24 post			1	84	<0.01	Seed	
						<0.01	Sheaths & stalks	
(Forage corn)	1.68 pre			1+				
	2.24 post			1	84	<0.01	Cob	
						0.07 (wet)	Sheath & stalks	
						0.21 (dry)		

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
USA, 1987					0B*	<0.025	Pre-emergence followed by 2 post-emergence directed sprays	Roper, 1989f A1IA-87-538
IA (Pioneer 3295)	1.12pre			1+				
	0.31post			2	43	<0.025	Forage	
						<0.025	Silage	
					79	<0.025	Kernels	
						<0.025	Fodder	
MI (Jacques)	1.12pre			1+				71MI-87-539
	0.31post			2	36	0.09	Forage	
						0.04	Silage	
					83	<0.025	Kernels	
						0.06	Fodder	
MD (Dekalb 524)	1.12pre			1+				64SD-87-540
	0.31post			2	39	<0.025	Forage	
					41	<0.025	Silage	
					95	<0.025	Kernels	
					95	<0.025	Fodder	
NB (NK9540)	1.12pre			1+				92NB-87-541
	0.31post			2	33	<0.025	Forage	
					47	<0.025	Silage	
					93	<0.025	Kernels	
						<0.025	Fodder	
WI (High Lysine 32)	1.12pre			1+				A1WI-87-543
	0.31post			2	51	<0.025	Forage	
						<0.025	Silage	
					86	<0.025	Kernels	
						<0.025	Fodder	
IL (Pioneer 3540)	1.12pre			1+				US04-87-544
	0.31post			2	28	<0.025	Forage	
					49	<0.025	Silage	
					80	<0.025	Kernels	
					80	<0.025	Fodder	
GA (Pioneer 3165)	1.12pre			1				83GA-87-557
	0.31pos			2	30	<0.025	Forage	
					41	<0.025	Silage	
					70	<0.025	Kernels	
					70	<0.025	Fodder	
NC (Pioneer 3369A)	1.12pre			1				61NC-87-558
	0.31pos			2	35	<0.025	Forage	
					35	<0.025	Silage	
					71	<0.025	Kernels	
					71	<0.025	Fodder	
TX (Pioneer 3380)	1.12pre			1				72TX-87-559
	0.31pos			2	63	<0.025	Forage	
					63	<0.025	Silage	
					93	<0.025	Kernels	
					93	<0.025	Fodder	
USA, 1988					B*	<0.025	Post-emergence directed	Roper 1989g
IA (Garst 8383)	0.56			1	0	2	Forage	35IA-88-440
					7	2		
					14	0.5		
					21	0.6		
					22	0.3	Silage	
	0.56			2	48	<0.025	Kernels	
						1	Fodder	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
IL (Agrigold A6445)	0.56			2	0	2		21IL-88-441
					7	3	Forage	
					14	2		
					21	3		
						1	Silage	
					56	≤0.025	Kernels	
						1	Fodder	
NE (NC+511)	0.56			2	0	0.6	Forage	41NB-88-442
					26	0.3		
					29	0.2	Silage	
					35	≤0.025	Kernels	
						0.2	Fodder	
OH (unknown)	0.56			2	0	1	Forage	25OH-88-443
					7	3		
					14	0.1		
					21	0.08		
					34	0.07	Silage	
					76	≤0.025	Kernels	
					76	0.03	Fodder	
SC (Pioneer 3165)	0.56			2	14	≤0.025	Kernels	46SC-88-444
						6	Fodder	
NC (Pioneer 3165)	0.56			2	0	0.3	Forage	47NC-88-445
					6	2		
					14	0.1		
					21	0.1		
					6	0.05	Silage	
					47	≤0.025	Kernels	
					47	0.05	Fodder	
SC (Pioneer 3165)	0.56			2	14	≤0.025	Kernels	46SC-88-446
					14	2	Fodder	
US, 1972					0B*	<0.01	Harvest aid	Chevron 1975b
GA (Coker 71)	0.56		47	1	7	0.03	Grain	T-2228
						3.2	Fodder	(pre-emergence x1)
	1.12		47	1	3	0.05	Grain	
					7	0.04	Grain	
						5.6	Fodder	
MS (Funks G-4761)	0.56		150	1	7	0.04	Grain	T-2229
	1.12		150	1	3	0.03	Grain	
					7	0.05	Grain	
IA (Pioneer 3369A)	0.56		187	1	7	0.03	Grain	T-2230
	1.12		187	1	3	0.05	Grain	
					7	0.07	Grain	
IL (Dekalb XL-66)	0.56		93	1	8	0.04	Grain	T-2231
						2.5	Fodder	
	1.12		93	1	3	0.05	Grain	
					8	0.03	Grain	
						4.4	Fodder	
USA, 1973					0B*	<0.01	Harvest aid	
IL (unknown)	0.56		23	1	7	<0.01	Grain	T-2789
						7.4	Fodder	
MS (Funks G-4761)	0.56		187	1	7	<0.01	Grain	T-2790
						7.8	Fodder	
						<0.01	Cobs (w/o kernel)	
GA (Coker 67)	0.56		47	1	7	0.01	Grain	T-2791
						1.1	Fodder	
IL (Funks G-4646)	0.56		28	1	7	0.01	Grain	T-2792
					8	6.8	Fodder	
					7	<0.01	Refined oil	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
MN (Funks 4433)	0.56		47	1	8	0.04	Grain	T-3106
						<0.01	Solvent extracted oil	
							Corn gluten feed	
						0.11	Grain	
	1.12		47	1	8	0.07	Solvent extracted oil	
						<0.01	Corn gluten feed	
						0.19		
IA (Pioneer 3366)	0.56		47	1	27	0.06	Grain	T-3108
						<0.01	Solvent extracted oil	
						0.02	Germ cake after extraction	
							Bran	
						0.06		

*B: control

Sorghum. Paraquat is recommended for use in the cultivation of sorghum as a pre-plant or pre-emergence treatment, as a post-emergence directed or guarded spray for inter-row weed control, or as a harvest aid desiccation.

Several residue trials were carried out in the USA over several years and locations in which paraquat was applied for weed control, either pre-emergence or post- directed, or as a harvest aid at rates of 0.21 to 7.8 kg ai/ha. In the pre-emergence or the post-emergence directed trials, sorghum was sampled 20 to 131 days post application. For harvest aid desiccation, paraquat was applied at rates of 0.21 to 2.8 kg/ha, with sampling 7 to 49 days after application. Residue levels of paraquat in fodder, silage, forage hay, hulls, and other processed fractions were measured.

Table 35. Paraquat residues in sorghum from supervised trials in the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
USA, 1967					0B*	<0.01	Post-emergence directed	Kalens *et al.* 1971
MS (BR-62)	0.56		280	1	48	<0.01	Forage	T-1286
					105	<0.01	Grain	
						<0.01	Fodder	
OK (RS 612)	0.56		280	1	35	0.01	Forage	T-1287
					105	<0.01	Grain	
						<0.01	Fodder	
TX (RS 671)	0.56		374	1	75	<0.01	Forage	T-1288
					106	<0.01	Grain	
						<0.01	Fodder	
MS (unknown)	0.56		280	1	49	<0.01	Forage	T-1289
					106	<0.01	Grain	
						<0.01	Fodder	
USA, 1971					0B*	<0.01	Pre-emergence followed by post-emergence directed	Kalens *et al.* 1971
MS (Funks BR 79)	0.28 pre		234	1+	36	<0.01	Forage	T-2155
	0.28 post			1	86	<0.01	Grain	
						<0.01	Fodder	
	0.56 pre		234	1+	36	<0.01	Forage	
	0.56 post			1	86	<0.01	Grain	
						0.01	Fodder	
TX (RS 671)	0.28 pre		206	1+	63	<0.01	Forage	T-2156
	0.28 post			1	131	<0.01	Grain	
						<0.01	Fodder	
	0.56 pre		206	1+	63	<0.01	Forage	
	0.56 post			1	131	0.01, 0.01	Grain	
						0.02, 0.02	Fodder	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
TX (DeKalb E 56)	0.56 pre		206	1+	40	<0.01	Forage	T-2157
	0.28 post			1	131	<0.01	Grain	
						<0.01	Fodder	
TX (NK 222)	0.56 pre		206	1+	40	<0.01	Forage	T-2159
	0.56 post			1	67	<0.01	Grain	
						<0.01	Fodder	
USA, 1969					0B*	<0.01	Harvest aid	Anon 1975a
CA (Lindsay 744)	0.21		206	1	7	0.04	Grain	T-1863
					21	0.04		
	0.43		206	1	7	0.11		
					21	0.06		
CA (Lindsay 744)	0.21		206	1	7	0.03	Grain	T-1864
					21	0.02		
	0.43		206	1	7	0.11		
					21	0.03		
TX (DeKalb C42)	0.21		9	1	7	0.22	Grain	T-1865
					21	0.04		(air)
	0.43		9	1	7	0.67		
					21	0.57		
TX (DeKalb C42)	0.21		9	1	7	0.17	Grain	T-1866
					21	0.12		(air)
	0.43		9	1	7	0.58		
					21	0.31		
NE (unknown)	0.21		47	1	7	0.08	Grain	T-1867
					21	0.07		(air)
	0.43		47	1	7	0.36		
					21	0.13		
NE (unknown)	0.21		47	1	7	0.14	Grain	T-1868
					21	0.09		(air)
	0.43		47	1	7	0.41		
					21	0.09		
USA, 1970					0B*	<0.008	Harvest aid	Anon 1975a
TX (DeKalb F65A)	0.21		47	1	7	0.47	Grain	T-2004
						0.06	Flour	(air)
						2.5	Bran	
						0.94	Shorts	
					24	0.27	Grain	
						0.05	Flour	
						1.0	Bran	
						0.43	Shorts	
CA (unknown)	0.21		47	1	7	0.71	Grain	T-2005
						0.31	Flour	(air)
					21	0.39	Grain	
						0.25	Flour	
USA, 1973					0B*	<0.01	Harvest aid	Anon 1975a
IA (unknown)	0.43		28	1	7	2.0	Grain	T-2778
						10	Fodder & Forage	(air)
NE (Pioneer 878)	0.43		28	1	8	2.5	Grain	T-2779
						0.10	Flour	(air)
						6.0	Bran	
						8.4	Shorts	
						0.86	Germ	
						5.6	Fodder	
IL (unknown)	0.43		131	1	7	28	Fodder	T-2780

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
NE (various)	1.12		234	1	24	0.16, 0.28, 0.22, 0.19, 0.26, 0.15	Grain	T-2977
						0.85, 0.49, 1.3, 0.69, 0.52, 0.91	Fodder	
	1.12		234	1	40	0.05	Grain (broadcast)	
						0.22	Fodder (broadcast)	
						0.06	Grain (direct)	
						0.18	Fodder (direct)	
					49	0.07	Grain (broadcast)	
						0.30	Fodder (broadcast)	
						0.07	Grain (direct)	
						0.26	Fodder (direct)	
USA, 1974					0B*	<0.01	Harvest aid	Anon 1975a
KA (Pioneer)	0.43pre		28	1+	7	1.3	Grain	T-3129
	0.43			1		3.7	Fodder	(air)
KA (Pioneer)	0.56 pre		28	1+	7	2.1	Grain	T-3130
	0.43			1		5.0	Fodder	(air)
NE (Prairie Valley 500)	0.43		28	1	7	2.0	Grain	T-3131
						4.8	Fodder	(air)
USA, 1987					0B*	<0.025	Pre-emergence and then post-emergence directed	Roper 1989k
TX (Pioneer 8493)	1.12 pre			1+				
	0.56 post			2	52	<0.025	Forage	72TX-87-570
						0.025	Silage	
						<0.025	Hay	
					86	<0.025	Fodder	
						<0.025	Grain	
NE (DeKalb DK41V)	1.12 pre			1+				92NB-87-571
	0.56 post			2	48	<0.025	Forage	
						0.025	Silage	
					62	0.06	Hay	
					73	0.03	Fodder	
						<0.025	Grain	
KS (Paymaster 1022)	1.12 pre			1+				48KS-87-572
	0.56 post			2	20	0.025	Forage	
						0.04	Silage	
					25	<0.025	Hay	
					72	0.06	Fodder	
						<0.025	Grain	
SD (Sokota 910GS)	1.12 pre			1+				64SD-87-573
	0.56 post			2	22	0.025	Forage	
						0.025	Silage	
						<0.025	Hay	
					67	0.03	Fodder	
						<0.025	Grain	
	7.85 pre			1+				64SD-87-573
	3.92 post			2	67	<0.025	Grain	E
NE (NC+172)	1.12 pre			1+				92NB-87-574
	0.56 post			2	29	0.06	Forage	
						0.04	Silage	
					41	0.09	Hay	
					65	<0.025	Fodder	
						<0.025	Grain	
	7.85 pre			1+				92NB-87-574
	3.92 post			2	65	<0.025	Grain	E
MO (Stauffer 530)	1.12 pre			1+				06MO-87-575
	0.56 post			2	44	0.04	Forage	
						0.2	Hay	
					56	<0.025	Fodder	
						<0.025	Grain	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
AZ (Funks G522DR Hybrid)	1.12 pre			1+				38AX-87-576
	0.56 post			2	35	<0.025	Forage	
						<0.025	Silage	
						0.04	Hay	
					61	<0.025	Fodder	
						<0.025	Grain	
AL (Funks GB125)	1.12 pre			1+				62AL-87-578
	0.56 post			2	23	<0.025	Forage	
						<0.025	Hay	
					70	<0.025	Fodder	
						<0.025	Grain	
AR (Stauffer 530)	1.12 pre			1+				06AR-87-579
	0.56 post			2	35	<0.025	Forage	
						<0.025	Hay	
					59	<0.025	Fodder	
						<0.025	Grain	
NC (Northrup King 2660)	1.12 pre			1+				US01-87-580
	0.56 post			2	36	0.025	Forage	
						0.025	Silage	
						0.04	Hay	
					61	0.05	Fodder	
						<0.025	Grain	
IL (Pioneer 6790)	1.12 pre			1+				US04-87-581
	0.56 post			2	32	<0.025	Forage	
						<0.025	Hay	
					39	<0.025	Silage	
					71	<0.025	Fodder	
						<0.025	Grain	
AZ (Dekalb DK42V)	1.12 pre			1+				
	0.56 post			2	28	0.2	Forage	
						0.34	Silage	
						0.2	Hay	
					48	0.1	Fodder	
						<0.025	Grain	
USA, 1988					0B*	<0.5; <1; <10	Harvest aid	Roper 1989j
TX (Golden Acres FE Y75)	2.8			1	3	12.5	Whole grain from field	11TX88-793
						10.4	Whole grain from processor	
						69.7	Dry milled bran	
						3.3	Coarse grits	
						3.6	Flour	
						44.8	Wet milled bran	
						1.4	Starch	
NE (NK2230)	2.8			1	7	26.4	Whole grain from field	41NB88-794
						9.2	Whole grain from processor	
						1.8	Hulled grain	
						51.6	Dry milled bran	
						2.2	Coarse grits	
						2.5	Flour	
						23.8	Wet milled bran	
						0.7	Starch	
USA, 2000					0B*	<0.02 grain <0.5 stover	Pre-emergence followed by a harvest aid desiccation	Carringer & Yuen 2001
NC (DK36)	1.12pre		184	1+	3	14	Grain	PARA-00-MR
	1.12post		184	1		18	Stover	-01-343

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
MS (Terral TV1050)	1.12pre 1.12post		226 237	1+ 1	3	304 13 2.5, 2.9, 3.2 2.6, 2.6, 2.5 81, 106, 107	Grain Stover Grain, dirty Grain, cleaned Aspirated grain fraction	PARA-00-MR -01-344
IL (Northrup King KS585)	1.12pre 1.12post		193 195	1+ 1	3	4.5 18	Grain Stover	PARA-00-MR -01-345
NE (NK 1486)	1.12pre 1.12post		93 91	1+ 1	3	4.6 23	Grain Stover	PARA-00-MR -01-346
NE (NK 1486)	1.12pre 1.12post		321 313	1+ 1	1 3 7 14	8.4 24 6.7 19 6.0 15 4.1 9.9	Grain Stover Grain Stover Grain Stover Grain Stover	PARA-00-MR -01-347
KS (NC+6B70)	1.12pre 1.12post		280 280	1+ 1	3	1.9 16	Grain Stover	PARA-00-MR -01-348
OK (Mycogen 730B)	1.12		243	1	3	5.6 40	Grain Stover	PARA-00-MR -01-349
TX (Sprint)	1.12pre 1.12post		237 236	1+ 1	3	4.9 39	Grain Stover	PARA-00-MR -01-350
NE (NK 1486)	1.12pre 1.12post		235 235	1+ 1	3	12 14	Grain Stover	PARA-00-MR -01-351
OK (TR432)	1.12pre 1.12post		279 279	1+ 1	3	5.2 33	Grain Stover	PARA-00-MR -01-352
TX (Cherokee)	1.12pre 1.12post		96 98	1+ 1	3	4.1 44	Grain Stover	PARA-00-MR -01-353
TX (9300)	1.12pre 1.12post		187 189	1+ 1	3	2.8 43	Grain Stover	PARA-00-MR -01-354

*B: control

Rice. Paraquat is recommended for use in the cultivation of rice as either a pre-plant or pre-emergence treatment to the seed beds for weed control.

In two residue trials in Italy in 1993 paraquat was applied at a rate of 0.92 kg ai/ha to the seed bed five days before sowing rice. Grain and straw samples were taken at harvest.

Two residue trials were conducted in Guatemala in 1983 where paraquat was applied as pre-emergence at rates of 0.60 and 1.0 kg ai/ha. Grain and straw samples were taken at harvest.

In residue trials in the USA in 1978 and 1982 paraquat was applied pre-emergence at rates of 0.56 and 1.12 kg ai/ha.

Table 36. Paraquat residues in rice from supervised trials in Guatemala, Italy and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Guatemala 1983 (Blue Belle)	0.60 1.00 0.30		400 400 400	1 1 1	0B* 108 108 108	<0.05 <0.05 <0.05 <0.05	Pre-emergence Dehusked seed	Kennedy 1984a
Italy, 1993 (Loto) (Koral)	0.92 0.92		400 400	1 1	0B* 119 151	<0.05 ≤0.05 <0.05 ≤0.05 <0.05	5 days Pre planting grain straw grain straw	Anderson *et al* 1995 IT10-93-H370 IT10-93-H371

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, USA, 1978					0B*	<0.01 grain <0.02 straw	Pre-emergence	Anon 1985
(Calrose)	0.56		187	1	217	<0.01 <0.06	Grain Straw	M209-4642
(Calrose)	0.56		187	1	230	<0.01 <0.05	Grain Straw	M209-4641
CA, USA, 1982					0B*	<0.01 grain <0.02, <0.03 straw	Pre-emergence	Anon 1985
(M-9)	0.56		93.5	1	163	<0.01 <0.03	Grain Straw	M209-5650
(M-301)	0.56		93.5	1	166	<0.01 <0.02	Grain Straw	M209-5651
	1.12		187	1	166	<0.01 <0.02	Grain Straw	
(M-101)	0.56		93.5	1	167	<0.01 0.04	Grain Straw	M209-5649
	1.12		187	1	167	<0.01 <0.03	Grain Straw	
(Labelle)	1.12		187	1	106	<0.01 <0.02	Grain Straw	M209-5583

*B: control

Tree nuts

Paraquat is registered to control weeds around the base of nut trees.

Supervised residue trials were carried out over a number of years in Italy on hazelnuts, and in the USA on almonds (California), macadamia nuts (Hawaii), pecans (Alabama and Texas), pistachio (California) and walnuts (California).

In trials in Italy hazelnuts were harvested from the ground between 1 and 10 days after treatment around the base of the trees at rates between 0.4 and 1.8 kg ai/ha.

In the USA, paraquat was applied at rates between 0.56 and 9.0 kg ai/ha from one to ten times, to control weeds under mature nut trees. In some cases applications were made over two years. Nuts were harvested, in some cases immature, from 1 to 171 days after the last application. In a worst-case situation, almonds were knocked off the tree and harvested from the ground only one day after the last application.

Table 37. Paraquat residues in tree nuts from supervised trials in Italy and the USA.

Country, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Italy, 1986 Hazelnuts (Gentile Romana)	0.54		1000	1	0B* 1 3 7 10	<0.05 <0.05 <0.05 <0.05 <0.05	Shelled nut analysed (picked from ground)	Gatti 1987
	0.89		1000	1	1 3 7 10	<0.05 <0.05 <0.05 <0.05		
	1.8		1000	1	1 3 7 10	<0.05 <0.05 <0.05 <0.05		
CA, USA Almonds					0B*	<0.01		Chevron 2001
1964								

Country, year Crop (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no.	PHI days	Paraquat mg/kg	Notes	References
(Non Pareil)	1.12		935	3	3	0.01	Whole nuts	T-603
					3	0.04	Whole terminals	Number in ():
(Texas)				4	26	<0.01	Hulls	application
					26	<0.01	Kernels	number in 1963
					26	0.01	Terminals	
(Non Pareil)				2	52	<0.01	Hulls, less shells	
					52	<0.01	Kernels	
(Non Pareil)	2.24		935	3(2)	3	0.02	Whole nuts	
					3	0.07	Whole terminals	
(Texas)				4(2)	26	<0.01	Kernels	
					26	<0.01	Hulls	
					26	<0.01	Terminals	
(Non Pareil)				2(2)	52	<0.01	Hulls, less shells	
					52	0.01	Kernels	
1966								T-1088
(Nonpareil)	1.12		206	4(1)	1	<0.01	Hulls	Number in ():
					1	<0.01	Nuts	application
								number in 1964
(Non pariel)	1.12		34	4(1)	1	0.07	Hulls	T-1089
					1	0.02	Kernels	nuts knocked to
								treated ground
(Non pariel)	1.12		34	4(1)	1	0.22	Hulls	T-1090
					1	0.01	Kernels	nuts knocked to
								treated ground
HI, USA					0B*	<0.01		Chevron 2001
Macademia nuts								
1962								
(Standard)	0.90			2	44	<0.01	Kernels	T-321
	1.23			2	44	<0.01	Kernels	
	1.57			2	44	<0.01	Kernels	
(Keahou)	0.56			3	6	<0.01	Kernels	T-333
					26	<0.01	Kernels	
	1.40			3	6	<0.01	Kernels	
					26	<0.01	Kernels	
1964								T-609
(Keahou)	0.56		468	3	30	<0.01	Whole nuts	Number in ():
				4	73	<0.01	Nut Kernels	application
				3(4)	65	<0.01	Whole nuts	number in 1963
				4(4)	73	<0.01	Nut Kernels	
	1.12		468	3(4)	65	0.01	Whole nuts	
				4(4)	73	<0.01	Nut Kernels	
1985								T-6617
(Keahou)	0.56		281	1	1	<0.01	Nut meat	Dried for 14 days
				2	1	0.02	Nut meat	before shelling
	0.28		281	1	1	0.01	Nut meat	Nuts were hulled
				2	1	0.01	Nut meat	on day of
								sampling
AL, USA, 1962					0B*	<0.01		Chevron 2001
Pecans								
(Mixed)	2.24		1870	6	49	<0.01	Nut meat	T-345
	4.48		1870	6	49	<0.01	Nut meat	
USA					0B*	<0.05		Ross *et al.* 1978
OR, 1972 Filberts (unknown)	1.12			1	134	<0.05	Nut meat	
GA, 1977 Pecans (unknown)	1.12			1	161	<0.05	Nut meat	
AL, 1977 Pecans (unknown)	1.12			1	171	<0.05	Nut meat	

*B: control

Oil seed

Paraquat is recommended for use in the cultivation of cotton and sunflowers as a pre-plant or pre-emergence treatment, a post-emergence directed or guarded spray for inter-row weed control, and for harvest aid desiccation.

Several trials were conducted for over several years and locations in the USA on cotton involving pre-emergence applications at 0.14 to 1.12 kg/ha with harvest 4 to 176 days post application. In numerous trials with a pre-emergence followed by a harvest aid desiccation application, cotton was harvested after 3 to 11 days.

In 1988 trials in the USA, paraquat was applied pre-emergence to sunflowers at 1.12 or 5.6 kg/ha and with sampling 41 to 131 days post application. In other US trials in various years and locations, paraquat was applied for harvest aid desiccation at 0.28 to 1.12 kg/ha with sampling 7 to 21 days post application.

Table 38. Paraquat residues in cotton and sunflowers from supervised trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1963 (Acala 4-42)					0B*	<0.01	Pre-emergence	Chevron 1967 T-383
	1.12		468	1	121	<0.01	Seed	
						<0.01	Trash	
						<0.01	Lint	
CA, 1964 (Acala 4-42)	1.12		468	1	30	<0.01, <0.01	Whole plant	T-614
					60	<0.01, <0.01		
					154	<0.01, <0.01		
CA, 1965 (Acala 4-42)	1.12		187	1	0B*	<0.02		T-771
					147	0.02, 0.04	Fuzzy seed	
MS, 1966 (Stoneville 213)	1.12		187	1	172	<0.01, <0.01	Fuzzy seed	T-1123
LA, 1966 (DPL smootleaf)	1.12		187	1	176	<0.01, <0.01	Fuzzy seed	T-1124
AR, 1966 (Rex)	1.12		374	1	171	<0.01, <0.01	Fuzzy seed	T-1125
1971					0B*	<0.01	Pre-emergence followed by harvest aid desiccation	Whipp & Kalens 1972
MS (Delta pine land 16)	0.56 pre		187	1+				
	0.14 post		187	1	4	0.21, 0.25	Fuzzy seed	T-2151
MS (Stoneville 213)	0.56 pre		187	1+				T-2152
	0.14 post		187	1	7	0.12, 0.12	Fuzzy seed	
LA (Coker 201)	0.56 pre		187	1+				T-2153
	0.14 post		187	1	7	0.07, 0.12	Fuzzy seed	
LA (Rex smooth leaf 66)	0.56 pre		187	1+				T-2154
	0.14 post		187	1	4	0.11, 0.18	Fuzzy seed	
1964					0B*	<0.01	Harvest aid desiccation	Chevron 1966 T-655
TX (Delta pine)	0.28			1	9.5	0.02, 0.02, 0.03, 0.04	Fuzzy seed	
	0.56			1	9.5	0.03, 0.07, 0.14, 0.17	Fuzzy seed	
MS (DPL15)	0.28			1	10	<0.01, <0.01, 0.06, 0.07	Fuzzy seed	T-656
	0.56			1	10	0.02, 0.02, 0.02, 0.03	Fuzzy seed	
CA (Acala 4-42)	0.28			1	11	<0.01, <0.01, <0.01, <0.01	Fuzzy seed	T-657
	0.56			1	11	<0.01, <0.01, <0.01, <0.01	Fuzzy seed	
CA (Acala 4-42)	0.14			1	5	<0.01, <0.01	Fuzzy seed	T-659
					11	<0.01, <0.01		

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
TX (Blightmaster)	0.56			1	9	0.97, 0.97, 1.28, 1.76	Cotton (including trash & bolls)	T-654
					9	0.08, 0.09, 0.10, 0.18	Fuzzy seed	
					9	<0.01, <0.01, <0.01, <0.01	Acid-delinted seed	
					9	<0.01, <0.01, <0.01, 0.01	Mechanically delinted seed	
					9	<0.01, <0.01, <0.01, 0.01	Hulls	
					9	<0.01, <0.01, <0.01, <0.01	Crude oil	
					9	<0.01, <0.01, <0.01, <0.01	Meal	
TX (Rex)	0.56			1	1	15, 15	Cotton (including trash & bolls)	T-653
					5	2.1, 2.6		
					10	2.0, 2.1		
					5	0.11, 0.13	Fuzzy seed	
					10	0.18, 0.18		
					10	0.05, 0.051	Acid-delinted seed	
					10	0.08, 0.08	Mechanically delinted seed	
					10	2.8, 3.3	Lint cotton	
					10	0.13, 0.13	Hulls	
					10	<0.01, <0.01	Crude oil	
					10	0.02, 0.02	Meal	
1965					0B*	<0.01	Harvest aid desiccation	Chevron 1966
TX (Stoneville 7A)	0.28			1	10	0.03, 0.04	Fuzzy seed	T-742
TX (Stoneville 7A)	0.28			1	10	0.10, 0.15	Fuzzy seed	T-743
OK (Lankart 23-3)	0.28			1	9	0.03, 0.13	Fuzzy seed	T-745
TX (Stoneville 7A)	0.28			2	10	0.28, 0.31	Fuzzy seed	T-746
TX (Stoneville 7A)	0.28			2	7	0.13, 0.16	Fuzzy seed	T-747
OK (Lankart 23-3)	0.28			2	7	0.33, 0.40	Fuzzy seed	T-749
CA (Acala 4-42)	0.56			1	3	0.09, 0.12	Fuzzy seed	T-938
					5	0.18, 0.30		
CA (Acala 4-42)	0.56			1	3	0.11, 0.11	Fuzzy seed	T-939
					5	0.12, 0.15		
TX (Lankart 57)	0.42			1+				T-786
	0.28			1	4	0.10, 0.18	Fuzzy seed	
	0.56			1+				
	0.28			1	5	0.34	Fuzzy seed	
	0.90			1	6	0.62	Fuzzy seed	
1993					0B*	<0.05	Pre-emergence followed by post-emergence, harvest aid	Roper 1994
NM (Paymaster 792)	1.4pre			1+				13-NM-93-37 1
	0.14post			2+				
	0.56post			1	3	0.16	Seed	
					5	0.11		
	1.4pre			1+				
	0.84post			1	3	0.26	Seed	
					5	0.34		

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
TX (Paymaster 145)	1.4pre 0.14post 0.56post 1.4pre 0.84post			1+ 2+ 1 1+ 1	 3 6 3 5	 <0.05 0.09 0.10 0.12	 Seed Seed	13-TX-93-372
TX (DPL 5415)	1.4pre 0.14post 0.56post 1.4pre 0.84post			1+ 2+ 1 1+ 1	 3 5 3 5	 1.0 0.55 0.75 0.18	 Seed Seed	25-TX-93-373
1995 NC (Deltapine 90)	 1.4pre 0.56 0.14 0.56		 140 187 93 93	 1+ 2+ 2+ 1	0B* 3	<0.05 0.38	Pre-emergence followed by post-emergence, harvest aid Seed	Roper & Elvira 1996 01-NC-95-651
LA (DPL 5415)	1.4 pre 0.56 0.14 0.56		124 214 90 91	1+ 2+ 2+ 1	 3 3	 0.46 18	 Seed Gin byproduct	69-LA-95-652
MS (Stoneville 453)	1.4 pre 0.56 0.14 0.56		187 234 89/86 84	1+ 2+ 2+ 1	 1 3 7 14	 0.23 0.16 0.21 0.14	 Seed	05-MS-95-653
TN (DPL 50)	1.1 pre 0.56 0.14 0.56		128 279 86/88 88	1+ 2+ 2+ 1	 3	 0.44	 Seed	50-TN-95-654
TX (DPL 51)	1.4 pre 0.56 0.14 0.56		94 186/194 93/92 88	1+ 2+ 2+ 1	 3	 0.58	 Seed	25-TX-95-655
NM (Paymaster 145)	1.4 pre 0.56 0.14 0.56		128 216/212 93 93	1+ 2+ 2+ 1	 3	 0.16	 Seed	23-NM-95-656
TX (Paymaster 145)	1.4 pre 0.56 0.14 0.56		137 215/218 79/76 80	1+ 2+ 2+ 1	 3	 2.0 12	 Seed Gin byproduct	23-TX-95-658
TX (Paymaster HS200)	1.4 pre 0.56 0.14 0.56		137 215/225 79/78 75	1+ 2+ 2+ 1	 3	 0.50 8.0	 Seed Gin byproduct	23-TX-95-659
CA (Acala GC510)	1.4 pre 0.56 0.14 0.56		139 270/257 90/92 89	1+ 2+ 2+ 1	 3	 0.49 69	 Seed Gin byproduct	02-CA-95-660

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA (DP 5461)	1.4 pre		150	1+				14-CA-95-66
	0.56		187/222	2+				1
	0.14		77/78	2+				
	0.56		80	1	3	0.07	Seed	
AZ (DPL 20)	1.4 pre		104	1+				14-AZ-95-662
	0.56		126/127	2+				
	0.14		79/80	2+				
	0.56		80	1	3	0.23	Seed	
						23	Gin byproduct	
OK (Paymaster HS200)	1.4 pre		136	1+				23-OK-95-66
	0.56		185/192	2+				3
	0.14		69/68	2+				
	0.56		67	1	3	0.35	Seed	
						5.3	Gin byproduct	

B=control

Table 39. Paraquat residues in sunflower seed from supervised trials in the USA.

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
1988					0B*	<0.05	Pre-emergence	Roper 1989o
SD (Interstate 893)	5.6			1	84	<0.05	Forage	31SD-88-475
					131	<0.05	Seed	
ND (Pioneer 6445)	5.6		215	1	B*	<0.05	Forage	34ND-88-476
					74	<0.05	Seed	
					122	<0.05		
ND (Pioneer 6440)	1.1			1	74	<0.05	Forage	34ND-88-528
					122	<0.05	Seed	
SD (unknown)	1.1			1	84	<0.05	Forage	31SD-88-529
					131	<0.05	Seed	
MN (NK285)	1.1			1	76	<0.05	Forage	33MN-88-530
					111	<0.05	Seed	
TX (Texas Triumph 565)	1.1		210	1	41	<0.05	Forage	10TX-88-531
					118	<0.05	Seed	
1994					0B*	<0.05	Pre-emergence; post directed; & harvest aid	Roper 1995
ND (Pioneer DO 827)	1.12		142	1+			Seed	34ND-94-202
	0.70		59	1+				
	0.56		142	1	7	0.93		
SD, (Cargill 100)	1.12		142	1+				34SD-94-203
	0.70		59	1+				
	0.56		142	1	7	0.74	Seed	
1971					0B*	<0.01	Harvest aid	Chevron 1975a
CA (Peredovik)	0.28		374	1	0	0.08, 0.08	Seed	T-2185
					7	0.10, 0.11	Seed	
						0.23, 0.27	Hull	
						0.17, 0.12	Meal	
						<0.01, <0.01	Oil	
					14	0.11, 0.11	Seed	
	0.56		374	1	0	0.16, 0.16	Seed	
					7	0.35, 0.35	Seed	
						0.57, 0.67	Hull	
						0.54, 0.55	Meal	
						<0.01, <0.01	Oil	
					14	0.23, 0.23	Seed	
MS (NK-HO1)	0.28		46	1	0	0.05, 0.11	Seed	T-2186
					7	0.10, 0.31	Seed	
						1.3, 2.4	Hull	
						0.64, 1.2	Meal	
						<0.01, <0.01	Oil	
					14	0.38, 0.52	Seed	
	0.56		46	1	0	0.19, 0.19	Seed	

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
					7	0.27, 0.34	Seed	
						2.2, 4.6	Hull	
						0.60, 0.71	Meal	
						<0.01, <0.01	Oil	
					14	0.49, 0.81	Seed	
1972					0B*	<0.01	Harvest aid	Chevron 1975a
MN (VNIIMK 8931)	0.28		47	1	7	0.05, 0.11	Seed	T-2392
						0.07, 0.08	Hulls	
						0.10, 0.14	Meal	
						<0.01, <0.01	Oil	
					14	0.09, 0.13	Seed	
						0.07, 0.10	Hulls	
						0.17, 0.23	Meal	
						<0.01, <0.01	Oil	
					21	0.11, 0.12	Seed	
						0.07, 0.09	Hulls	
						0.11, 0.15	Meal	
						<0.01, <0.01	Oil	
	0.56		47	1	7	0.04, 0.04	Seed	
					14	0.32, 0.52	Seed	
					21	0.81, 0.42	Seed	
MN (VNIIMK 8931)	0.28		47	1	7	0.06, 0.06	Seed	T-2393
						0.06, 0.06	Hulls	
						0.02, 0.10	Meal	
						<0.01, <0.01	Oil	
					14	0.03, 0.04	Seed	
						0.04, 0.06	Hulls	
						0.05, 0.07	Meal	
						<0.01, <0.01	Oil	
					21	0.02, 0.04	Seed	
						0.02, 0.02	Hulls	
						0.04, 0.05	Meal	
						<0.01, <0.01	Oil	
	0.56		47	1	7	0.21, 0.27	Seed	
					14	0.37, 0.39	Seed	
					21	0.32, 0.60	Seed	
CA (HO-1)	0.28		206		7	0.12, 0.14	Seed	T-2394
						0.14, 0.16	Hulls	
						0.17, 0.20	Meal	
						<0.01, <0.01	Oil	
					14	0.09, 0.11	Seed	
						0.11, 0.14	Hulls	
						0.17, 0.20	Meal	
						<0.01, <0.01	Oil	
					21	0.10, 0.11	Seed	
						0.08, 0.11	Hulls	
						0.18, 0.18	Meal	
						<0.01, <0.01	Oil	
	0.56		206		7	0.35, 0.51	Seed	
					14	0.40, 0.44	Seed	
					21	0.23, 0.26	Seed	
1973					0B*	<0.01	Harvest aid	Chevron 1975a
IA (Peredovik)	0.28		187	1	7	0.10, 0.13	Seed	T-2679
						0.30, 0.32	Hulls	
						<0.01, <0.01	Meal	
						<0.01, <0.01	Oil	
	1.1		187	1	7	0.18, 0.19	Seed	
						0.53, 0.54	Hulls	
						<0.01, 0.01	Meal	
						<0.01, <0.01	Oil	
						17, 18	Leaves	
						8.3, 8.4	Stalks	

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
ND (Peredovik)	0.56		47	1	7	0.16, 0.16	Seed	T-2680
						0.56, 0.58	Hulls	
						<0.01, 0.01	Meal	
						<0.01, <0.01	Oil	
						8.1, 11	Leaves	
						4.8, 5.2	Stalks	
					14	0.10, 0.11	Seeds	
					21	0.05, 0.05	Seeds	
CA (RHA-271)	0.56		206	1	7	0.09	Seed	T-2681
						0.27	Hulls	
						<0.01	Meal	
						<0.01	Oil	
					14	0.05	Seed	
MS (HF-52)	0.56		47	1	7	0.12, 0.14	Seed	T-2682
						0.36, 0.40	Hulls	
						<0.01, <0.01	Meal	
						<0.01, <0.01	Oil	
					14	0.09, 0.10	Seed	
					21	0.07, 0.09	Seed	
SD (Record)	0.63		23	1	14	0.15, 0.16	Seed	T-2683
						0.42, 0.50	Hulls	
						0.01, 0.02	Meal	
						<0.01, <0.01	Oil	
MN (Cargill 101)	0.56		47	1	9	0.20, 0.22	Seed	T-2684
						0.60, 0.64	Hulls	
						0.02, 0.02	Meal	
						<0.01, <0.01	Oil	
1974					0B*	<0.01	Harvest aid	Chevron 1975a
MN (Sputnik)	0.56		47	1	7	0.12, 0.16	Seed	T-3069
						0.25, 0.30	Hulls	
						0.08, 0.09	Meal	
						<0.01, <0.01	Oil	
ND (Sputnik)	0.56		47	1	7	0.24, 0.24	Seed	T-3070
						0.50, 0.59	Hulls	
						0.11, 0.14	Meal	
						<0.01, <0.01	Oil	
SD (Peredovik)	0.56		47	1	7	0.28, 0.32	Seed	T-3071
TX (sun Hi 372)	0.56		47	1	15	0.18, 0.19	Seed	T-3126
						0.39, 0.40	Hulls	
						0.09, 0.13	Meal	
						<0.01, <0.01	Oil	
					20	0.14, 0.16	Seed	
TX (Sun Hi 372)	0.56		47	1	17	0.12, 0.15	Seed	T-3127

B=control

Hops

Paraquat is recommended for the control of weeds pre-emergence or post-emergence directed between hop rows.

In Canada, a single post-emergence directed application of 1.12 kg ai/ha was made and green hops were harvested 42 days after application.

In residue trials in the USA in the States of Idaho and Washington, using three post-emergence directed applications of paraquat at 2.8 kg ai/ha green hops were harvested 13 to 14 days after the last application and processed into dried hops.

Table 40. Paraquat residues in hops from supervised trials in Canada and the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
BC, Canada, 1964 (Unknown)	2.24		702-935	1	0B*	<0.01	Post-emergence directed	McKenna 1966
					53	<0.01	Green hops	
ID, USA, 1988 (Hallertau Mittlefrueh)	2.8	9.03	31	3	B*	<0.05	Green hops	Roper 1989d 15ID88-591
						<0.1	Dried hops	
					14	<0.05	Green hops	
						<0.1	Dried hops	
WA, USA, 1988 (L-1 Clusters)	2.8	9.03	31	3	B*	<0.05	Green hops	15WA88-592
						<0.1	Dried hops	
					13	<0.05	Green hops	
						<0.1	Dried hops	
OR, USA, 1973					B*	<0.01	Green hops	Anon. 1975b
						<0.01	Dried hops	
	0.56			3	14	0.04	Green hops	T-2639
(Cascade)						0.05	Dried hops	
	1.12			3	14	0.05	Green hops	
						0.01	Dried hops	
(Fuggle)	0.56		374	1+				T-2640
	1.12			1	14	0.03	Green hops	
						0.03	Dried hops	
	1.12			1+				
	2.24			1	14	0.01	Green hops	
						0.02	Dried hops	
(Bullion)	0.56		467	3	14	0.04	Green hops	T-2958
						0.05	Dried hops	
	1.12			3	14	0.03	Green hops	
						0.07	Dried hops	
(Bullion)	1.12		187	3	31	<0.01	Dried hops	T-2967
						<0.01	Refuse	
	2.24			3	31	<0.01	Dried hops	
						0.06	Refuse	

*B: control

Tea. Table 41 shows application rates per season. Paraquat was applied as one initial blanket spraying plus 1, 3 or 5 spot treatments for weed-infested areas over a period of 5-7 months. Green leaf samples from each plot were taken 0-21 days after the first blanket treatment and at intervals after subsequent spot treatments, and processed into black tea by the orthodox (4NET) or CTC method (other than 4NET). The orthodox method consists of withering the leaves until the moisture is reduced to 20-25% and then repeatedly rolling the leaf in conventional three crank rollers. Leaves are then fermented at normal temperature. The fermentation is stopped by firing the leaves. In the CTC (crushing, tearing and curling) method the withered leaves as above are fed into a commercial machine consisting of two milled and chased rollers running at a ratio of 1:10. The leaves are then fermented under controlled temperature and humidity before firing in a drying machine.

Table 41. Paraquat residues in black tea from supervised trials in India.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha		water, l/ha	no.				
Jorhat, 1994 (Khorijan & Timgamira Jat)	0		500 (blanket)		7	<0.05		Anderson & Agarwal 1996 1 NET
					21	<0.05		
					7	<0.05		
					21	<0.05		
					7	<0.05		
	0.57	1 blanket 3 spot			7	<0.05	after blanket treatment	
					21	<0.05	after 1st spot treatment	
					7	<0.05	after last spot	
					21	<0.05	treatment	
					7	<0.05	after blanket treatment	
							after 1st spot treatment	
	1.6	1 blanket 3 spot			7	0.07	after last spot	
					21	<0.05	treatment	
					7	<0.05		
					21	<0.05		
					7	<0.05		
Rajmai, 1994 (Betjan clone TVI)	0		500 (blanket)		7	<0.05		2 NET
					21	<0.05		
					7	<0.05		
					21	<0.05		
					7	<0.05		
	0.68	1 blanket 3 spot			7	<0.05	after blanket treatment	
					21	<0.05	after 1st spot treatment	
					7	<0.05	after last spot	
					21	0.07	treatment	
					7	<0.05	after blanket treatment	
							after 1st spot treatment	
	2.0	1 blanket 3 spot			7	<0.05	after last spot	
					21	<0.05	treatment	
					7	<0.05		
					21	0.05		
					7	<0.05		
Nagrakata, India 1994 (biclonal selections)	0		500 (blanket)	1	7	<0.05		3 NET
					21	<0.05		
					7	<0.05		
					21	0.05		
	0.56	1 blanket 1 spot		1	7	<0.05	after blanket treatment	
					21	<0.05	after 1st (last) spot	
					7	<0.05	treatment	
					21	<0.05	after blanket treatment	
	1.7	1 blanket 1 spot		1	7	<0.05	after 1st (last) spot	
					21	<0.05	treatment	
					7	<0.05		
					21	<0.05		
Darjeeling, 1994 (China hybrid)	0		500 (blanket)		7	<0.05		4 NET
					21	<0.05		
					7	<0.05		
					21	<0.05		
					7	<0.05		
	0.57	1 blanket 3 spot			7	<0.05	after blanket treatment	
					21	<0.05	after 1st spot treatment	
					7	<0.05	after last spot	
					21	<0.05	treatment	
					7	<0.05	after blanket treatment	
							after 1st spot treatment	
	1.7	1 blanket 3 spot			7	<0.05	after last spot	
					21	<0.05	treatment	
					7	<0.05		
					21	<0.05		
					7	<0.05		

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and references	
	kg ai/ha		water, l/ha	no.				
Valpari, India 1994 (Upasi-17 clone)	0		500 (blanket)		7	<0.05		5 ST
					21	<0.05		
					7	0.13		
	0.56	1 blanket			7	0.09	after blanket treatment	
		5 spot			21	0.08	after last spot	
					7	0.07	treatment	
							after blanket treatment	
	1.7	1 blanket			7	0.09	after last spot	
		5 spot			21	0.08	treatment	
					7	0.07		
Munnar, India 1994 (China hybrid)	0		500 (blanket)		7	<0.05		6 ST
					21	<0.05		
					7	<0.05		
	0.56	1 blanket			7	<0.05	after blanket treatment	
		3 spot			21	0.12	after last spot	
					5	<0.05	treatment	
							after blanket treatment	
	1.7	1 blanket			7	<0.05	after last spot	
		3 spot			21	<0.05	treatment	
					5	<0.05		
Assam, India (Clone T3E3) Site I	0.25	0.06	400	1	5	0.05		Indian submission, 2004
					7	<0.05		
	0.19	0.05	400	1	5	<0.05		
					7	<0.05		
	0.19	0.05	400	1	5	<0.05		
					7	<0.05		
	0.19	0.05	400	1	5	<0.05		
					7	<0.05		

Animal feedingstuffs

Soya forage and hay or fodder

Table 42. Paraquat residues in soya beans from supervised trials in the USA.

Year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no				
1988					0B*	<0.025, <0.05	Pre-emergence	Roper 1989l
IN (Decalb CX324)	1.1				79	≤0.025	Forage	23IN-88-584
					96	≤0.05	Hay	
MS (Asgrow)	1.1				113	≤0.025	Forage	48MS-88-585
					113	≤0.05	Hay	
MN (Evans)	1.1				132	≤0.025	Forage	38MN-88-787
					147	≤0.05	Hay	
OH (unknown)	1.1				106	≤0.025	Forage	27OH-88-788
					106	≤0.05	Hay	
1987					OB*	<0.025	Pre-emergence, post-emergence directed	Roper 1989m
NE (Asgrow 3127)	1.1 pre 0.14 post			1+ 2				92NB-87-560
					52	≤0.025	Forage	
					63	≤0.025	Hay or fodder	
					88	<0.025	Seed	
IL (William 82)	1.1 pre 0.14 post			1+ 2				US04-87-561
					59	≤0.025	Forage	
					59	≤0.025	Hay or fodder	
					90	<0.025	Seed	

Year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no	PHI days	Paraquat mg/kg	Notes	References
IA (Pioneer 9271)	1.1 pre 0.14 post			1+ 2	 37 84 84	 <0.025 0.2 0.03	 Forage Hay or fodder Seed	A1IA-87-562
LA (Yield King 613)	1.1 pre 0.14 post			1+ 2	 19 48 63	 0.05 0.1 <0.025	 Forage Hay or fodder Seed	36LA-87-563
MS (Centennial)	1.1 pre 0.14 post			1+ 2	 65 79 79	 <0.025 0.05 <0.025	 Forage Hay or fodder Seed	US05-87-564
MO (Asgrow 3544)	1.1 pre 0.14 post			1+ 2	 53 102 102	 <0.025 <0.025 <0.025	 Forage Hay or fodder Seed	48MO-87-565
AR (DPL 504)	1.1 pre 0.14 post			1+ 2	 74 41 109	 <0.025 <0.025 <0.025	 Forage Hay or fodder Seed	06AR-87-566
AL (Braxton)	1.1 pre 0.14 post			1+ 2	 70 138 138	 <0.025 <0.025 <0.025	 Forage Hay or fodder Seed	62AL-87-567
GA (Kirby)	1.1 pre 0.14 post			1+ 2	 34 79 79	 <0.025 0.04 <0.025	 Forage Hay or fodder Seed	83GA-87-568
De (Pioneer 9441)	1.1 pre 0.14 post			1+ 2	 3 30 30	 1.8 0.3 <0.025	 Forage Hay or fodder Seed	44DE-87-569
1997					0B*	<0.05	Pre-emergence	Spillner *et al.* 1999
NC(Hyperformer 574)	1.4			1	36	0.08	Forage	01-NC-97-610
TN(Hutachson)					30	0.28		50-TN-97-611
AR(AG5901)					23	<0.05		49-AR-97-612
LA(Delta Pine					29	<0.05		69-LA-97-613
DP3478)					36	0.07		63-IA-97-615
IA(Pella)					36	0.15		63-IA-97-616
IA(D260)					42	<0.05		63-IA-97-617
IA(L2233)					44	<0.05		04-IL-97-618
IL(Asgrow A3237)					42	0.06		60-IL-97-619
IL(Asgrow 4401)					44	<0.05		60-IL-97-620
IL(Asgrow 2704 STS)					53	0.06		67-IN-97-621
IN(Pioneer 9342)					47	<0.05		67-IN-97-622
IN(Alder 373)					36	<0.05		37-KS-97-623
KS(Ciba 373)					40	<0.05		36-MN-97-624
MN(ICI D162)					42	<0.05		37-MO-97-625
MO(Ciba 3362)					50	<0.05		89-OH-97-627
OH(Asgrow 3701)					47	<0.05		34-SD-97-628
SD(Garst D210)					36	<0.05		79-WI-97-629
WI(Asgrow XP19505)					27	0.06		05-MS-97-631
MS(Asgrow 5979)					30	0.06		68-NE-97-632
NE(Pioneer 9281)					36	<0.05		79-WI-97-633
WI(Asgrow AG-2501)								
					0B*	<0.05	Pre-emergence, then two post-emergence directed then one spot application	Spillner *et al.* 1999

Year (variety)	Application kg ai/ha	kg ai/hl	water, l/ha	no	PHI days	Paraquat mg/kg	Notes	References
	1.40 pre			1+				
	0.56 post			2+				
NC(Hyperformer 574)	0.05 spot			1	46	<0.05	Hay	01-NC-97-610
TN(Hutachson)					28	0.70		50-TN-97-611
AR(AG5901)					21	1.36		49-AR-97-612
LA(Delta Pine					10	4.10		69-LA-97-613
DP3478)					14	0.79		63-IA-97-615
IA(Pella)					14	0.99		63-IA-97-616
IA(D260)					11	1.74		63-IA-97-617
IA(L2233)					8	3.21		04-IL-97-618
IL(Asgrow A3237)					11	1.15		
					14	1.19		
					18	0.74		
					25	0.49		
					26	0.88		60-IL-97-619
IL(Asgrow 4401)					22	0.67		60-IL-97-620
IL(Asgrow 2704 STS)					18	2.69		67-IN-97-621
IN(Pioneer 9342)					10	5.56		67-IN-97-622
IN(Alder 373)					18	0.09		37-KS-97-623
KS(Ciba 373)					22	0.82		36-MN-97-624
MN(ICI D162)					16	0.29		37-MO-97-625
MO(Ciba 3362)					27	1.04		68-NE-97-626
NE(Pineer 9281)					20	1.95		89-OH-97-627
OH(Asgrow 3701)					22	1.33		34-SD-97-628
SD(Garst D210)					8	0.33		05-MS-97-631
MS(Asgrow 5979)					29	0.34		
					32	0.57		
					35	0.18		
					43	0.49		
					18	0.33		79-WI-97-633
WI(Asgrow AG-2501)								
					0B*	<0.05	Pre-emergence; two post-emergence directed; one spot; one desiccation application	Spillner *et al.* 1999
1988					B*	<0.05	Forage	Roper 1989n
						<2	Hay	
						<0.05	Seed	
IL (Fayette)	2.24		38	1	0	20	Hay	22IL-88-458
					5	26	Forage	Ground
					10	24	Forage	application
					15	22	Forage	
					21	0.1	Seed	
IA (Pioneer 9271)	2.24		38	1	0	24	Forage	36IA-88-459
						45	Hay	Ground
					5	8	Forage	application
					10	9	Forage	
					15	9	Forage	
						0.05	Seed	
					B*	<25	Forage	
						<15	Hay	
						<0.05	Seed	
IN (Dekalb CX324)	2.24		38	1	0	78	Forage	23IN-88-460
					5	49	Forage	Ground
						70	Hay	application
					10	58	Forage	
					15	45	Forage	
						<0.05	Seed	

Year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no				
MS (DPL 506)	2.24		38	1	0	70	Forage	48MS-88-461
						124	Hay	Ground
					5	49	Forage	application
					10	88	Forage	
					15	73	Forage	
						0.05	Seed	
MO (Williams)	2.24		38	1	0	49	Forage	40MO-88-462
						29	Hay	Ground
					5	51	Forage	application
					11	54	Forage	
					15	43	Forage	
					20	0.1	Seed	
MN (Evans)	2.24		38	1	0	30	Forage	33MN-88-463
						16	Hay	Ground
					5	40	Forage	application
					10	29	Forage	
					15	24	Forage	
						0.1	Seed	
OH (unknown)	2.24		38	1	0	135	Forage	27OH-88-464
						140	Hay	Ground
					5	221	Forage	application
					10	125	Forage	
					15	161	Forage	
					36	2	Seed	
					B*	<0.05	Forage	
						<2	Hay	
						<0.05	Seed	
IL (Pioneer 9271)	2.24		38	1	0	20	Hay	22IL-88-536
					5	26	Forage	Aerial application
					10	24	Forage	
					15	22	Forage	
					21	0.1	Seed	
IA (Sieben SS-235)	2.24		38	1	0	0.12	Forage	36IA-88-537
						80	Hay	Aerial application
					5	10	Forage	
					10	15	Forage	
					15	9	Forage	
						0.2	Seed	
IN (Century)	2.24		38	1	0	29	Forage	24IN-88-538
					5	26	Forage	Aerial application
						23	Hay	
					10	25	Forage	
					15	13	Forage	
					25	<0.05	Seed	
MS (DPL 506)	2.24		38	1	1	38	Forage	48MS-88-539
						31	Hay	Aerial application
					5	27	Forage	
					10	47	Forage	
					15	33	Forage	
					15	0.2	Seed	
MO (Williams 82)	2.24		38	1	0	19	Forage	37MO-88-540
						38	Hay	Aerial application
					5	10	Forage	
					10	10	Forage	
					15	<5	Forage	
					19	0.1	Seed	
MN (BSR 101)	2.24		38	1	0	59	Forage	30MN-88-541
						2	Hay	Aerial application
					5	23	Forage	
					10	23	Forage	
					15	22	Forage	
					22	0.08	Seed	

Year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no				
					B*	<1	Forage	
						<2	Hay	
						<0.05	Seed	
OH (Asgrow 3427)	2.24		38	1	0	15	Forage	27OH-88-542
						6	Hay	Aerial application
					5	19	Forage	
					10	8	Forage	
					15	1	Forage	
						0.08	Seed	

B*: control

Sugar beet tops

Table 43. Paraquat residues in beet from supervised trials in the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
UK, 1964	1.68 pre		N/A	1+	112	<0.01	Root	McKenna 1966
Beetroot	2.24 direct			2		0.01	Tops	
(unknown)								
UK, 1964	1.68 pre		N/A	2+	72	0.01	Root	McKenna 1966
Sugar Beet	2.24 direct			1		0.08	Tops	
(Klein)								
	1.68 pre		N/A	2+	84	<0.01	Root	
	2.24 direct			1		0.06	Tops	
USA, 1988	1.12		N/A	1	0B*	<0.025	Pre-emergence	Roper 1989c
Sugar Beet					136	<0.05	Root	33MN88-405
(unknown)						≤0.025	Top	
					138	<0.05	Root	33ND88-406
						≤0.025	Top	
					151	<0.05	Root	17CA88-403
						≤0.025	Top	
					152	<0.05	Root	34ND88-407
						≤0.025	Top	
					160	<0.05	Root	16ID88-404
						≤0.025	Top	
					178	<0.05	Root	73CA88-402
						≤0.025	Top	

*B: control

Maize forage and fodder

Table 44. Paraquat residues in maize forage and fodder from supervised trials in Canada, Italy, South Africa, the UK and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Italy, 1993					0B*	<0.05	Pre-emergence	Anderson & Lant 1994
(Pioneer 3471)	0.92		521	1	104	<0.05	Silage	IT10-93-H385
					136	<0.05	Cob	
(Pioneer 3471)	0.92		483	1	104	<0.05	Silage	IT10-93-H386
					136	<0.05	Cob	
USA, 1987					0B*	<0.025	Pre-emergence followed by 2 post-emergence directed sprays	Roper, 1989f A1IA-87-538
IA (Pioneer 3295)	1.12pre 0.31post			1+ 2	43	≤0.025	Forage	
						<0.025	Silage	
					79	<0.025	Kernels	
						≤0.025	Fodder	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
MI (Jacques)	1.12pre			1+				71MI-87-539
	0.31post			2	36	0.09	Forage	
						0.04	Silage	
					83	<0.025	Kernels	
						0.06	Fodder	
MD (Dekalb 524)	1.12pre			1+				64SD-87-540
	0.31post			2	39	≤0.025	Forage	
					41	<0.025	Silage	
					95	<0.025	Kernels	
					95	≤0.025	Fodder	
NB (NK9540)	1.12pre			1+				92NB-87-541
	0.31post			2	33	≤0.025	Forage	
					47	<0.025	Silage	
					93	<0.025	Kernels	
						≤0.025	Fodder	
WI (High Lysine 32)	1.12pre			1+				A1WI-87-543
	0.31post			2	51	≤0.025	Forage	
						<0.025	Silage	
					86	<0.025	Kernels	
						≤0.025	Fodder	
IL (Pioneer 3540)	1.12pre			1+				US04-87-544
	0.31post			2	28	≤0.025	Forage	
					49	<0.025	Silage	
					80	<0.025	Kernels	
					80	≤0.025	Fodder	
GA (Pioneer 3165)	1.12pre			1				83GA-87-557
	0.31pos			2	30	≤0.025	Forage	
					41	<0.025	Silage	
					70	<0.025	Kernels	
					70	≤0.025	Fodder	
NC (Pioneer 3369A)	1.12pre			1				61NC-87-558
	0.31pos			2	35	≤0.025	Forage	
					35	<0.025	Silage	
					71	<0.025	Kernels	
					71	≤0.025	Fodder	
TX (Pioneer 3380)	1.12pre			1				72TX-87-559
	0.31pos			2	63	≤0.025	Forage	
					63	<0.025	Silage	
					93	<0.025	Kernels	
					93	≤0.025	Fodder	
USA, 1988					B*	<0.025	Post-emergence directed	Roper 1989g 35IN-88-440
IA (Garst 8383)	0.56			1	0	2	Forage	
					7	2		
					14	0.5		
					21	0.6		
					22	0.3	Silage	
	0.56			2	48	<0.025	Kernels	
						1	Fodder	
NE (NC+511)	0.56			2	0	0.6	Forage	41NB-88-442
					26	0.3		
					29	0.2	Silage	
					35	<0.025	Kernels	
						0.2	Fodder	
OH (unknown)	0.56			2	0	1	Forage	25OH-88-443
					7	3		
					14	0.1		
					21	0.08		
					34	0.07	Silage	
					76	<0.025	Kernels	
					76	0.03	Fodder	
SC (Pioneer 3165)	0.56			2	14	<0.025	Kernels	46SC-88-444
						6	Fodder	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
NC (Pioneer 3165)	0.56			2	0	0.3	Forage	47NC-88-445
					6	2		
					14	0.1		
					21	0.1		
					6	0.05	Silage	
					47	<0.025	Kernels	
					47	0.05	Fodder	
SC (Pioneer 3165)	0.56			2	14	<0.025	Kernels	46SC-88-446
					14	2	Fodder	
US, 1972					0B*	<0.01	Harvest aid	Chevron 1975b
GA (Coker 71)	0.56		47	1	7	0.03	Grain	T-2228
						3.2	Fodder	(pre-emergence x1)
	1.12		47	1	3	0.05	Grain	
					7	0.04	Grain	
						5.6	Fodder	
IL (Dekalb XL-66)	0.56		93	1	8	0.04	Grain	T-2231
						2.5	Fodder	
	1.12		93	1	3	0.05	Grain	
					8	0.03	Grain	
						4.4	Fodder	
USA, 1973					0B*	<0.01	Harvest aid	
IL (unknown)	0.56		23	1	7	<0.01	Grain	T-2789
						7.4	Fodder	
MS (Funks G-4761)	0.56		187	1	7	<0.01	Grain	T-2790
						7.8	Fodder	
						<0.01	Cobs (w/o kernel)	
GA (Coker 67)	0.56		47	1	7	0.01	Grain	T-2791
						1.1	Fodder	
IL (Funks G-4646)	0.56		28	1	7	0.01	Grain	T-2792
					8	6.8	Fodder	
					7	<0.01	Refined oil	

*B: control

Sorghum forage (green) and straw and fodder, dry

Table 45. Paraquat residues in sorghum forage (green) and straw and fodder, dry, from supervised trials in the USA.

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
1967					0B*	<0.01	Post-emergence directed	Kalens *et al.* 1971
MS (BR-62)	0.56		280	1	48	<0.01	Forage	T-1286
					105	<0.01	Grain	
						<0.01	Fodder	
OK (RS 612)	0.56		280	1	35	0.01	Forage	T-1287
					105	<0.01	Grain	
						<0.01	Fodder	
TX (RS 671)	0.56		374	1	75	<0.01	Forage	T-1288
					106	<0.01	Grain	
						<0.01	Fodder	
MS (unknown)	0.56		280	1	49	<0.01	Forage	T-1289
					106	<0.01	Grain	
						<0.01	Fodder	
1971					0B*	<0.01	Pre-emergence followed by post-emergence directed	Kalens *et al.* 1971
MS (Funks BR 79)	0.28 pre		234	1+	36	<0.01	Forage	T-2155
	0.28 post			1	86	<0.01	Grain	
						<0.01	Fodder	

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
	0.56 pre 0.56 post		234	1+ 1	36 86	<0.01 <0.01 0.01	Forage Grain Fodder	
TX (RS 671)	0.28 pre 0.28 post 0.56 pre 0.56 post		206 206	1+ 1 1+ 1	63 131 63 131	<0.01 <0.01 <0.01 <0.01 0.01, 0.01 0.02, 0.02	Forage Grain Fodder Forage Grain Fodder	T-2156
TX (DeKalb E 56)	0.56 pre 0.28 post		206	1+ 1	40 131	<0.01 <0.01 <0.01	Forage Grain Fodder	T-2157
TX (NK 222)	0.56 pre 0.56 post		206	1+ 1	40 67	<0.01 <0.01 <0.01	Forage Grain Fodder	T-2159
1973 IA (unknown)	 0.43		 28	 1	0B* 7	<0.01 2.0 10	Harvest aid Grain Fodder & Forage	Anon 1975a T-2778 (air)
NE (Pioneer 878)	0.43		28	1	8	2.5 0.10 6.0 8.4 0.86 5.6	Grain Flour Bran Shorts Germ Fodder	T-2779 (air)
IL (unknown)	0.43		131	1	7	28	Fodder	T-2780
NE (various)	1.12 1.12		234 234	1 1	24 40 49	0.16, 0.28, 0.22, 0.19, 0.26, 0.15 0.85, 0.49, 1.3, 0.69, 0.52, 0.91 0.05 0.22 0.06 0.18 0.07 0.30 0.07 0.26	Grain Fodder Grain (broadcast) Fodder (broadcast) Grain (direct) Fodder (direct) Grain (broadcast) Fodder (broadcast) Grain (direct) Fodder (direct)	T-2977
1974 KA (Pioneer)	 0.43pre 0.43		 28	 1+ 1	0B* 7	<0.01 1.3 3.7	Harvest aid Grain Fodder	Anon 1975a T-3129 (air)
KA (Pioneer)	0.56 pre 0.43		28	1+ 1	7	2.1 5.0	Grain Fodder	T-3130 (air)
NE (Prairie Valley 500)	0.43		28	1	7	2.0 4.8	Grain Fodder	T-3131 (air)
1987 TX (Pioneer 8493)	 1.12 pre 0.56 post			 1+ 2	0B* 52 86	<0.025 ≤0.025 0.025 <0.025 ≤0.025 <0.025	Pre-emergence and then post-emergence directed Forage Silage Hay Fodder Grain	Roper 1989k 72TX-87-570
NE (DeKalb DK41V)	1.12 pre 0.56 post			1+ 2	 48 62 73	 ≤0.025 0.025 0.06 0.03 <0.025	 Forage Silage Hay Fodder Grain	92NB-87-571

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
KS (Paymaster 1022)	1.12 pre			1+				48KS-87-572
	0.56 post			2	20	0.025	Forage	
						0.04	Silage	
					25	<0.025	Hay	
					72	0.06	Fodder	
						<0.025	Grain	
SD (Sokota 910GS)	1.12 pre			1+				64SD-87-573
	0.56 post			2	22	0.025	Forage	
						0.025	Silage	
						<0.025	Hay	
					67	0.03	Fodder	
						<0.025	Grain	
NE (NC+172)	1.12 pre			1+				92NB-87-574
	0.56 post			2	29	0.06	Forage	
						0.04	Silage	
					41	0.09	Hay	
					65	<0.025	Fodder	
						<0.025	Grain	
MO (Stauffer 530)	1.12 pre			1+				06MO-87-575
	0.56 post			2	44	0.04	Forage	
						0.2	Hay	
					56	<0.025	Fodder	
						<0.025	Grain	
AZ (Funks G522DR Hybrid)	1.12 pre			1+				38AX-87-576
	0.56 post			2	35	≤0.025	Forage	
						<0.025	Silage	
						0.04	Hay	
					61	<0.025	Fodder	
						<0.025	Grain	
AL (Funks GB125)	1.12 pre			1+				62AL-87-578
	0.56 post			2	23	≤0.025	Forage	
						<0.025	Hay	
					70	≤0.025	Fodder	
						<0.025	Grain	
AR (Stauffer 530)	1.12 pre			1+				06AR-87-579
	0.56 post			2	35	≤0.025	Forage	
						<0.025	Hay	
					59	≤0.025	Fodder	
						<0.025	Grain	
NC (Northrup King 2660)	1.12 pre			1+				US01-87-580
	0.56 post			2	36	0.025	Forage	
						0.025	Silage	
						0.04	Hay	
					61	0.05	Fodder	
						<0.025	Grain	
IL (Pioneer 6790)	1.12 pre			1+				US04-87-581
	0.56 post			2	32	≤0.025	Forage	
						<0.025	Hay	
					39	<0.025	Silage	
					71	≤0.025	Fodder	
						<0.025	Grain	
AZ (Dekalb DK42V)	1.12 pre			1+				
	0.56 post			2	28	0.2	Forage	
						0.34	Silage	
						0.2	Hay	
					48	0.1	Fodder	
						<0.025	Grain	
2000					0B*	<0.02 grain <0.5 stover	Pre-emergence followed by a harvest aid desiccation	Carringer & Yuen 2001
NC (DK36)	1.12pre		184	1+	3	14	Grain	PARA-00-MR
	1.12post		184	1		18	Stover	-01-343

Year, location (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
IL (Northrup King KS585)	1.12pre 1.12post		193 195	1+ 1	3	4.5 18	Grain Stover	PARA-00-MR -01-345
NE (NK 1486)	1.12pre 1.12post		93 91	1+ 1	3	4.6 23	Grain Stover	PARA-00-MR -01-346
NE (NK 1486)	1.12pre 1.12post		321 313	1+ 1	 1 3 7 14	 8.4 24 6.7 19 6.0 15 4.1 9.9	 Grain Stover Grain Stover Grain Stover Grain Stover	PARA-00-MR -01-347
KS (NC+6B70)	1.12pre 1.12post		280 280	1+ 1	3	1.9 16	Grain Stover	PARA-00-MR -01-348
OK (Mycogen 730B)	1.12		243	1	3	5.6 40	Grain Stover	PARA-00-MR -01-349
TX (Sprint)	1.12pre 1.12post		237 236	1+ 1	3	4.9 39	Grain Stover	PARA-00-MR -01-350
NE (NK 1486)	1.12pre 1.12post		235 235	1+ 1	3	12 14	Grain Stover	PARA-00-MR -01-351
OK (TR432)	1.12pre 1.12post		279 279	1+ 1	3	5.2 33	Grain Stover	PARA-00-MR -01-352
TX (Cherokee)	1.12pre 1.12post		96 98	1+ 1	3	4.1 44	Grain Stover	PARA-00-MR -01-353
TX (9300)	1.12pre 1.12post		187 189	1+ 1	3	2.8 43	Grain Stover	PARA-00-MR -01-354

*B: control

Rice straw and fodder, dry

Table 46. Paraquat residues in rice straw and fodder, dry, from supervised trials in Guatemala, Italy and the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Italy, 1993					0B*	<0.05	5 days Pre planting	Anderson *et al* 1995
(Loto)	0.92		400	1	119	<0.05 <0.05	grain straw	IT10-93-H370 IT10-93-H371
(Koral)	0.92		400	1	151	<0.05 <0.05	grain straw	
CA, USA, 1978					0B*	<0.01 grain <0.02 straw	Pre-emergence	Anon 1985
(Calrose)	0.56		187	1	217	<0.01 <0.06	Grain Straw	M209-4642
(Calrose)	0.56		187	1	230	<0.01 <0.05	Grain Straw	M209-4641
CA, USA, 1982					0B*	<0.01 grain <0.02, <0.03 straw	Pre-emergence	Anon 1985
(M-9)	0.56		93.5	1	163	<0.01 <0.03	Grain Straw	M209-5650
(M-301)	0.56 1.12		93.5 187	1 1	166 166	<0.01 <0.02 <0.01 <0.02	Grain Straw Grain Straw	M209-5651
(M-101)	0.56 1.12		93.5 187	1 1	167 167	<0.01 0.04 <0.01 <0.03	Grain Straw Grain Straw	M209-5649
(Labelle)	1.12		187	1	106	<0.01 <0.02	Grain Straw	M209-5583

*B: control

Almond hulls

Table 47. Paraquat residues in almond hulls from supervised trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes and reference	
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, USA					0B*	<0.01		Chevron 2001
1964								
(Non Pareil)	1.12		935	3	3	0.01	Whole nuts	T-603
					3	0.04	Whole terminals	Number in ():
(Texas)				4	26	≤0.01	Hulls	application
					26	<0.01	Kernels	number in 1963
					26	0.01	Terminals	
(Non Pareil)				2	52	≤0.01	Hulls, less shells	
					52	<0.01	Kernels	
(Non Pareil)	2.24		935	3(2)	3	0.02	Whole fruit	
					3	0.07	Whole terminals	
(Texas)				4(2)	26	<0.01	Kernels	
					26	<0.01	Hulls	
					26	<0.01	Terminals	
(Non Pareil)				2(2)	52	<0.01	Hulls, less shells	
					52	0.01	Kernels	
1966								T-1088
(Nonpareil)	1.12		206	4(1)	1	≤0.01	Hulls	Number in ():
					1	<0.01	Nuts	application
								number in 1964
(Non pariel)	1.12		34	4(1)	1	0.07	Hulls	T-1089
					1	0.02	Meat	nuts knocked to
								treated ground
(Non pariel)	1.12		34	4(1)	1	0.22	Hulls	T-1090
					1	0.01	Meat	nuts knocked to
								treated ground

*B: control

Cotton

Table 48. Paraquat residues in cotton from supervised trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
					0B*	<0.01	Pre-emergence	Chevron 1967
CA, 1963 (Acala 4-42)	1.12		468	1	121	<0.01	Seed	T-383
						<0.01	Trash	
						<0.01	Lint	
CA, 1964 (Acala 4-42)	1.12		468	1	30	≤0.01, <0.01	Whole plant	T-614
					60	<0.01, <0.01		
					154	<0.01, <0.01		
TX (Blightmaster)	0.56			1	9	0.97, 0.97, 1.28, 1.76	Cotton (including trash & bolls)	T-654
					9	0.08, 0.09, 0.10, 0.18	Fuzzy seed	
					9	<0.01, <0.01, <0.01, <0.01	Acid-delinted seed	
					9	<0.01, <0.01, <0.01, 0.01	Mechanically delinted seed	
					9	<0.01, <0.01, <0.01, 0.01	Hulls	
					9	<0.01, <0.01, <0.01, <0.01	Crude oil	
					9	<0.01, <0.01, <0.01, <0.01	Meal	

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
TX (Rex)	0.56			1	1	15, 15	Cotton (including trash & bolls)	T-653
					5	2.1, 2.6		
					10	2.0, 2.1		
					5	0.11, 0.13	Fuzzy seed	
					10	0.18, 0.18		
					10	0.05, 0.051	Acid-delinted seed	
					10	0.08, 0.08	Mechanically delinted seed	
					10	2.8, 3.3	Lint cotton	
					10	0.13, 0.13	Hulls	
					10	<0.01, <0.01	Crude oil	
					10	0.02, 0.02	Meal	
1989							Harvest aid	Roper 1990
					0B*	<1.0	Gin trash	
TX (Paymaster 145)	0.56			1	14	11	Gin trash	10TX-89-481
TX (Paymaster 145)	0.56			1	14	7.3	Gin trash	10TX-89-482
TX (DPL 50)	0.56			1	17	6.2	Gin trash	11TX-89-483
TX (DPL 50)	0.56			1	17	5.9	Gin trash	12TX-89-484
OK (Tamcot CD-3H)	0.56			1	14	12	Gin trash	13OK-89-485
AZ (D&PL 61)	0.56			1	14	5.2	Gin trash	14TX-89-486
AZ (D&PL 61)	0.56			1	14	9.4	Gin trash	14TX-89-487
CA (GC510)	0.56			1	13	32	Gin trash	19CA-89-488
CA (GC510)	0.56			1	13	34	Gin trash	19CA-89-489
USA, 1995					0B*	<0.05	Pre-emergence followed by post-emergence, harvest aid	Roper & Elvira 1996
LA (DPL 5415)	1.4 pre		124	1+				69-LA-95-652
	0.56		214	2+				
	0.14		90	2+				
	0.56		91	1	3	0.46	Seed	
					3	18	Gin byproduct	
TX (Paymaster 145)	1.4 pre		137	1+				23-TX-95-658
	0.56		215/218	2+				
	0.14		79/76	2+				
	0.56		80	1	3	2.0	Seed	
						12	Gin byproduct	
TX (Paymaster HS200)	1.4 pre		137	1+				23-TX-95-659
	0.56		215/225	2+				
	0.14		79/78	2+				
	0.56		75	1	3	0.50	Seed	
						8.0	Gin byproduct	
CA (Acala GC510)	1.4 pre		139	1+				02-CA-95-660
	0.56		270/257	2+				
	0.14		90/92	2+				
	0.56		89	1	3	0.49	Seed	
						69	Gin byproduct	
AZ (DPL 20)	1.4 pre		104	1+				14-AZ-95-662
	0.56		126/127	2+				
	0.14		79/80	2+				
	0.56		80	1	3	0.23	Seed	
						23	Gin byproduct	
OK (Paymaster HS200)	1.4 pre		136	1+				23-OK-95-663
	0.56		185/192	2+				
	0.14		69/68	2+				
	0.56		67	1	3	0.35	Seed	
						5.3	Gin byproduct	

B: control

FATE OF RESIDUES IN STORAGE AND PROCESSING

In processing

The Meeting received information on processing studies on the following **commodities.**

Crop	**Studied processed products**
Orange:	Juice
Plum:	Dried prunes
Grape:	Dried grapes and grape juice
Olive:	Washed fruit, oil and press cake
Tomato:	Juice, wet pomace, dry pomace and ketchup
Sugar Beet:	Molasses and refined sugar
Potato:	crisps, dried potato and granules
Maize:	germ, starch, grits, meal, flour and oil
Sorghum:	Bran, starch, grits and flour
Cotton seed:	Trash/gin by-products and oil
Sunflower seed:	Meal and oil
Hop:	Dried hop and beer

In order to investigate the degradation of paraquat residues during processing, typical processing studies were conducted. As the standard analytical methods for paraquat involve a rigorous acid reflux extraction (0.5M sulphuric acid reflux for 5 hours), the stability of paraquat to hydrolysis has been demonstrated. Studies showed paraquat to be stable the pH range of 5-9.

For those crops where paraquat is applied pre-emergence, post-emergence, or directly between crops, paraquat must not have direct contact with the crop, so and for this reason, under these applications, the extent the exposure of the crop to paraquat is minimal. The supervised field trials demonstrated the absence of, or very low residues of, paraquat in these crops, which would make processing studies unnecessary.

However, with harvest aid desiccant uses, the direct application of paraquat to the crop may result in much higher levels of residues, while in some cases orchard fruit under unusual conditions may come in contact with sprayed weeds. In these cases, processing studies were needed, to determine whether residues of paraquat are transferred and concentrated in the processed products.

The transfer factors are calculated by dividing the residues measured in the processed commodity by the residues measured in the raw agricultural commodity. The residue data used for the calculations are uncorrected for recovery values and expressed in mg paraquat cation/kg.

Processing of oranges

The fate of paraquat residue in oranges during juicing was investigated in studies in California and Florida, USA, with exaggerated application rates of 4.48 to 20.2 kg ai/ha as directed broadcast between the rows (Chevron, 2001). These rates are 4 to 18 times the highest permitted rate in US GAP. Oranges were collected between 0 and 177 days after application and processed to juice as described in Figure 6.

Table 49 shows that even at an exaggerated rate of application, no quantifiable residues of paraquat were found in any processed sample (limit of quantification: 0.01 mg/kg for peel and juice).

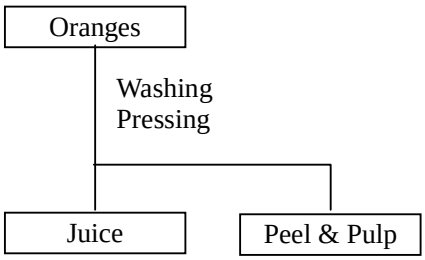


Figure 6. Processing of oranges to juice.

Table 49. Paraquat residues in oranges and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1962 (Navel)	2.8	0.12		2	0B*	<0.01		Chevron 2001 T-326
					0	<0.01	Juice (procedural recovery, 45%)	
					7	<0.01		
					15	<0.01		
					28	<0.01		
					0	<0.01		
					7	<0.01	Pulp (procedural recovery, 67%)	
					15	<0.01		
					28	<0.01		
FL, 1965 (Valencia)					0B*	<0.01		T-631 Broadcast spray around each tree on an area of 100 sq ft.
	1.12	0.054		4	177	<0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	
	2.24	0.054		9	31	<0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	
		0.11		4	177	<0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	
FL, 1965 (Hamlin)	2.44	0.12		1	0B*	<0.01		T-903
					3	0.01, <0.01	Mature fruit	
						<0.01, <0.01	Juice	

B*: control

Since the residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably calculated.

Processing of plums

Two plum trials were used to obtain field-incurred residues in plums for processing into dried plums. In two trials conducted in the USA, paraquat was applied to the ground round plum trees as a broadcast directed spray three times during the season at 4.48 kg/ha (Roper, 1989a). This rate is 4 times the highest label rate in the USA. The fruit were harvested 28 days after treatment. Some of these fresh prunes were dried for 16 hours in a commercial fruit drier to produce dried prunes (Figure 7). Residues were measured in fresh plums and dried prunes and the results are shown in Table 50.

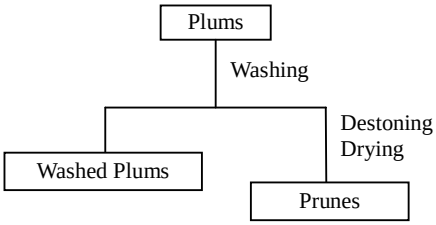


Figure 7. Processing of plums to prunes.

Table 50. Paraquat residues in plums and dried prunes from trials in the USA.

Location, year Crop (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1987 (Prune, French)	4.48	1.93		3	B* 28	<0.01 <0.05 <0.01 <0.05	Fresh Dried Fresh Dried	Roper 1989a 45CA-87-523
	4.48	1.93		3	B* 28	<0.01 <0.05 <0.01 <0.05	Fresh Dried Fresh Dried	45CA-87-599

B*:control

Since residues of paraquat in all the samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of grapes

One residue trial in grapes was conducted during 1997 in California, USA (Spillner, 1998). Paraquat was applied once at an exaggerated rate of 5.6 kg/ha as a broadcast between the rows. This rate is 5 times the highest application rate on labels. Grapes were collected on the day of application and processed into sun-dried grapes (sun-dried for 21 days) and grape juice simulating industrial practice as closely as possible. The paraquat residues in grapes, dried grapes and juice were determined. The processing of fresh grapes into dried grapes and juice is shown in Figure 8. Residues measured in grapes, raisins, and juice are shown in Table 51. The limit of quantification was 0.01 mg/kg for grapes and grape juice, and 0.05 mg/kg for dried grapes.

No quantifiable residues of paraquat were found in any treated or untreated sample.

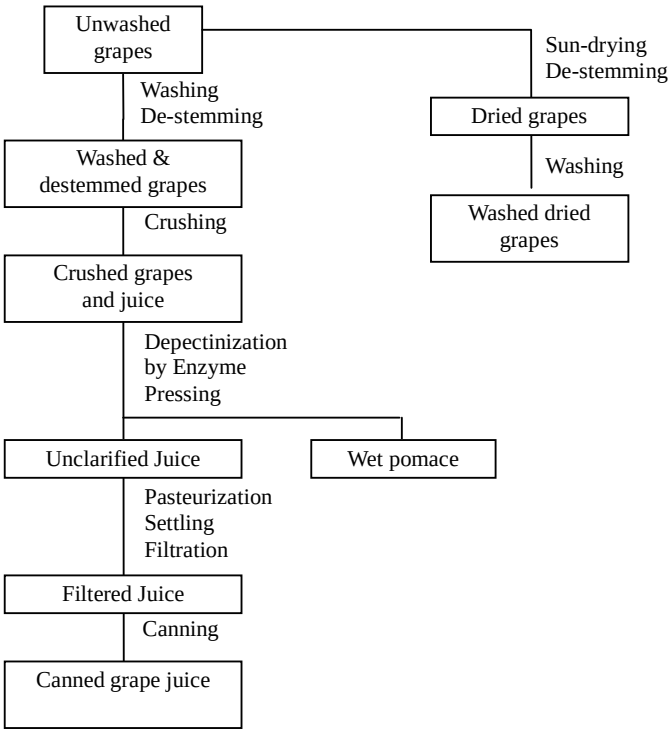


Figure 8. Processing of grapes to dried grapes and grape juice.

Table 51. Paraquat residues in grapes, dried grapes and juice from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	no.				
CA, 1997 (Thompson Seedless)	5.6		45.6	1	B*	<0.01	Berries	Spillner *et al.* 1998 02CA-97-601
						<0.01	Juice	
						<0.05	Dried grapes	
					21	<0.01	Berries	
						<0.01	Dried grapes	
						<0.05	Processed Juice	

B*=control

Since residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of olives

Olives destined for oil production are often harvested from the ground and paraquat may occasionally be applied directly to the fallen fruit when used to control weeds growing through the collection nets on the ground. These whole fruits will contain some paraquat residue, either through transfer from treated vegetation or through direct exposure. Studies were therefore conducted to investigate paraquat residues in oil and cake processed from olive fruits.

In a US trial in 1988, paraquat was applied four times at 5.6 kg ai/ha (a total of 22.4 kg ai/ha) to the soil at the base of the trees and olives were harvested 13 days after the last application. The application rate is five times the highest application rate on US labels (Roper, 1989i).

Two residue trials were carried out on olives in Italy in 1993 in which a single application of paraquat at a rate of 1.56 kg ai/ha and diquat at 0.78 kg ai/ha was applied for inter-row weed control. Olives were harvested 7 days after treatment to determine residues in olives and oil (Dick *et al.*, 1995a).

In these studies none of the samples of olives or contained paraquat residues above the limit of quantification.

Two new trials were conducted on olive trees in Spain during 2001 and 2002 (Devine *et al.*, 2003). Three or seven days before normal harvest, paraquat was applied once at a nominal rate of 1.1 kg ai/ha to fallen olives and the harvesting area around the base of the trees in two treated plots. Olive fruit samples for residue analysis were taken at normal harvest. Olive fruits for processing were taken from the untreated plant and the plots treated 3 days before harvest. These samples (unwashed olives) were processed into washed olives, virgin oil and refined oil, which were then analysed.

A flow chart for olive processing is shown in Figure 9 and the results of analysis in Table 52.

In the trial in the USA, paraquat was applied four times at an exaggerated rate (5.6 kg paraquat/ha; 22.4 kg/ha total) and the fruit were harvested from the trees for processing into oil and cake. In other trials in Spain, mature olives were sprayed directly on the ground with paraquat at rates from 0.36 to 1.3 kg/ha. The fruit were analysed after 3-17 days and the residue of paraquat ranged from 0.08 to 4.4 mg/kg.

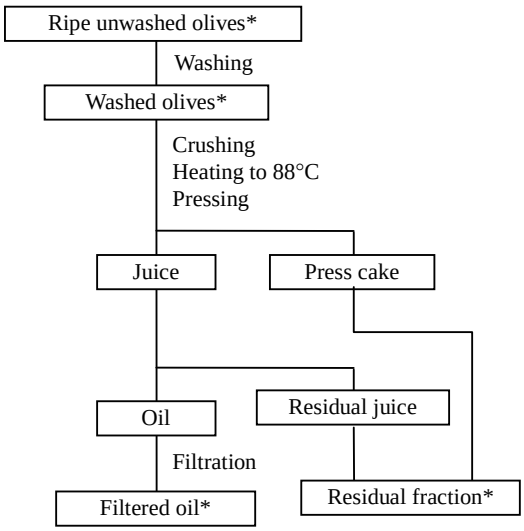


Figure 9. Processing of olives to oil.

Table 52. Paraquat residues in olives and their processed products from trials conducted in Italy, Spain, and the USA.

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
USA	5.6			4	B*	<0.05, <0.05	Fruit	Roper 1989i
1988						<0.05	Residual fraction	73CA88-526
(Manzanilla)						<0.05	Oil	
					13	<0.05, <0.05	Fruit	
						<0.05	Residual fraction	
						<0.05	Oil	
Latina, Italy,	1.56		1000	1	B*	<0.10	Fruit	Dick *et* al.
1993						<0.05	Oil	1995a
(Frantoio)					7	<0.10	Fruit	IT10-93-H338
						<0.05	Oil	
Foggia, Italy	1.56		1000	1	B*	<0.10	Fruit	IT10-93-H339
1993						<0.05	Oil	
(Coratina)					7	<0.10	Fruit	
						<0.05	Oil	

Country, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	no.				
Andalucia, Spain, 2001/2002 (Hojiblanca)	1.09		347	1			Mean % of treated olives: 24%	Devine *et* al. 2003 ES051-01-S013
					B*	<0.05		
					3	0.45	Fresh fruit	
					3	0.18	Unwashed fruit	
					3	0.11	Washed fruit	
					3	<0.05	Virgin oil	
					3	<0.05	Refined oil	
Catalonia, Spain, 2001/2002 (Arbequina)	1.05		192				Mean % of treated olives: 10%	ES060-01-S113
					B*	<0.05		
					3	0.09	Fresh fruit	
					3	0.06	Unwashed fruit	
					3	<0.05	Washed fruit	
					3	<0.05	Virgin oil	
					3	<0.05	Refined oil	

B*: control

The procedural recoveries in the analysis of virgin oil and refined oil were relatively low at 66 and 62% respectively.

Processing factors were calculated from the Spanish trials where residues in the fresh fruit were above the limit of quantification. The results are shown in Table 53.

Table 53. Processing factors from olives to oil.

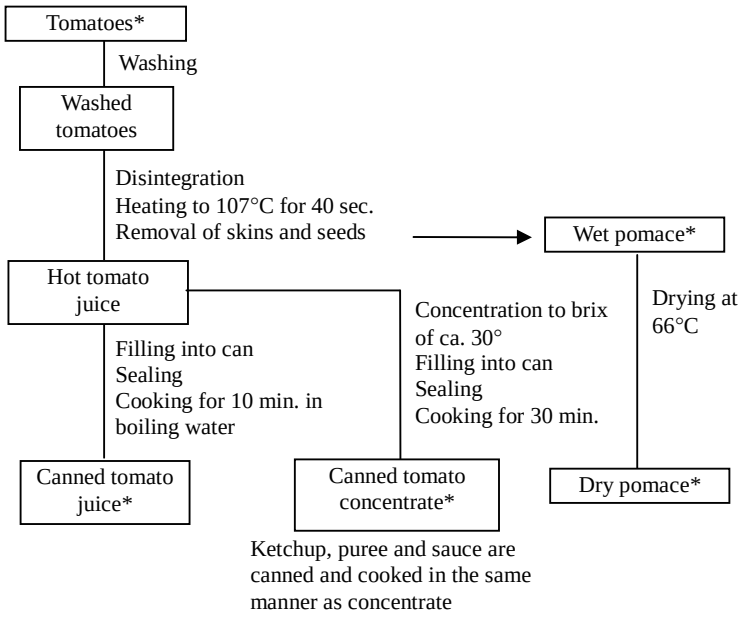
Product	ES051-01-S013		ES051-01-S113	
	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
Fresh Olive	0.38		0.09	
Unwashed olives before processing	0.18	0.47	0.06	0.67
Washed olives before processing	0.11	0.29	<0.05	<0.56
Virgin Oil	<0.05	<0.13	<0.05	<0.56
Refined oil	<0.05	<0.13	<0.05	<0.56

Paraquat is not transferred into the oil. Washing reduces paraquat residues to a certain extent.

Processing of tomatoes

In a study in the USA in 1988 whole tomatoes were treated with one pre-emergence broadcast application of paraquat at a rate of 1.12 kg ai/ha followed by three directed applications at 2.8 kg ai/ha (about 5 times the highest current application rate). Ripe tomatoes were harvested 30 days after the last application and processed according to normal commercial practice. The limits of quantification were 0.005 mg/kg for whole tomatoes and juice; 0.025 mg/kg for ketchup and wet pomace, and 0.05 mg/kg for dry pomace (Roper, 1989q).

A flow diagram outlining the processing is shown in Figure 10 and the results of residue analysis in Table 54. All residues of paraquat in all samples were below the limit of quantification.



* analysed samples

Figure 10. Processing of tomatoes to canned juice, canned tomatoes, canned concentrate, and wet and dry pomace

Table 54. Paraquat residues in tomatoes and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
CA, 1988 (Jackpot)					B*	<0.005	Unwashed tomato	Roper 1989q 18CA88-789
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
	1.12		38.2	1				
	2.8			3	30	<0.005	Unwashed tomato	
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
CA, USA, 1988 (Jackpot)					B*	<0.005	Unwashed tomato	18CA88-790
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	
	1.12		38.2	1				
	2.8			3	30	<0.005	Unwashed tomato	
						<0.005	Juice	
						<0.025	Ketchup	
						<0.025	Wet pomace	
						<0.05	Dry Pomace	

B*=control

Since residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of sugar beet

A study was conducted in the USA to determine paraquat residues in dehydrated pulp, molasses and refined sugar produced from sugar beet treated with one pre-emergence broadcast application of paraquat at a rate of 5.6 kg ai/ha, which is five times the normal rate in the USA. The beets were harvested at normal harvest, 137 days after treatment, and processed according to normal commercial practice. The limits of quantification were 0.05 mg/kg for roots, dry pulp and molasses, and 0.025 mg/kg for wet pulp and sugar (Roper, 1989c). A flow chart for sugar beet processing is shown in Figure 11 and the results of residue analysis are shown in Table 55.

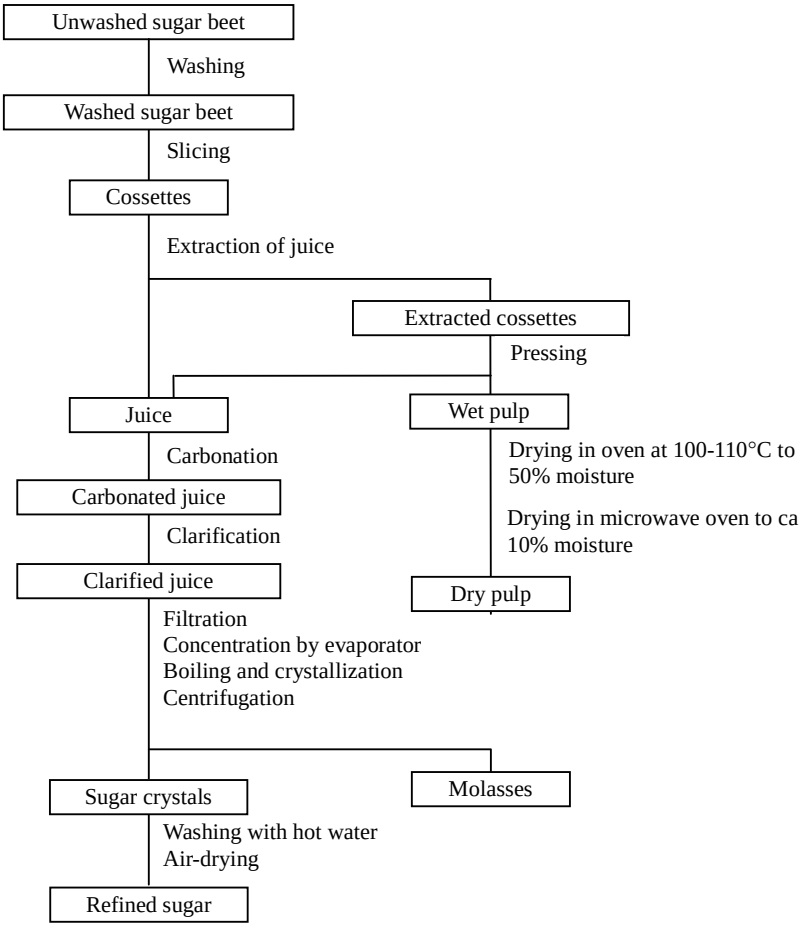


Figure 11. Processing of sugar beet to refined sugar, molasses and wet and dry pulp.

Table 55. Paraquat residues in sugar beet and processed products from a trial in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
ID, 1988	5.6		31	1	B*	<0.05	Unwashed roots from field	Roper 1989c 16ID88-599
						<0.05	Washed roots	
						<0.025	Wet pulp	
						<0.05	Dry pulp	
						<0.05	Molasses	
						<0.025	Sugar	
					137	<0.05	Unwashed roots from field	
						<0.05	Washed roots	
						<0.025	Wet pulp	
						<0.05	Dry pulp	
						<0.05	Molasses	
						<0.025	Sugar	

B*: control

Since residues of paraquat in all samples were below the limit of quantification, processing factors could not reliably be calculated.

Processing of potatoes

A study was conducted in Idaho and Maine, USA, to determine paraquat residues in potato tubers, wet and dried peel, crisps (chips) and granules from potatoes from plants treated with one broadcast spray of paraquat as a pre-harvest desiccant at 2.8 kg ai/ha seven days prior to harvest. Samples of unwashed potato tubers were washed and processed into potato crisps (chips) and granules according to the process described in Figure 12. The limits of quantification were 0.025 mg/kg for washed potatoes, peeled potatoes and potato crisps, 0.05 mg/kg for unwashed potatoes, peel and granules, and 0.025 mg/kg for dried peel (Roper, 1989b). The analytical results are shown in Table 56.

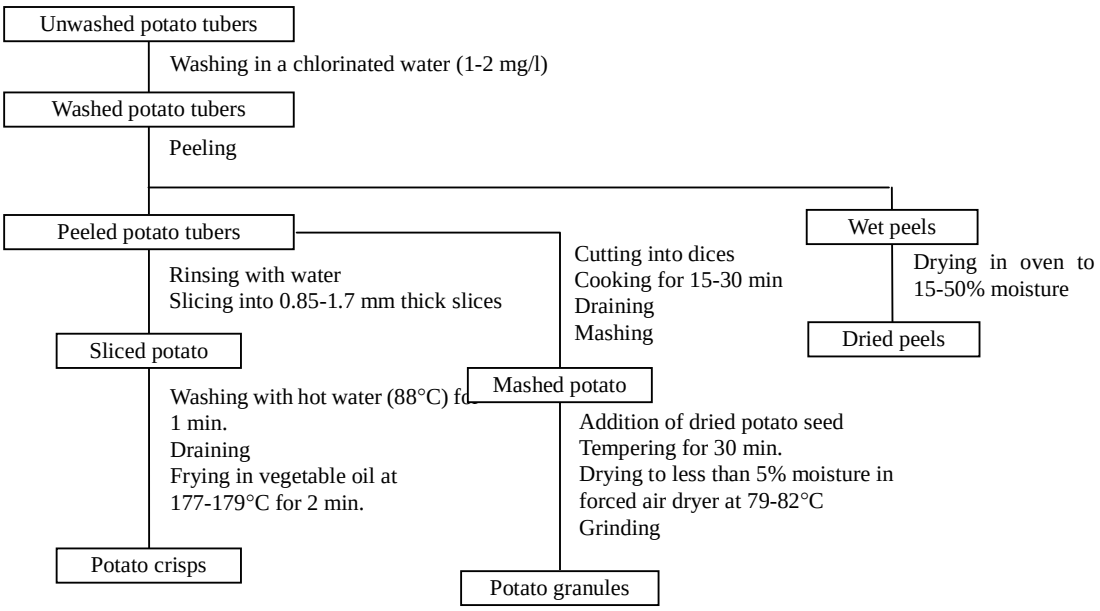


Figure 12. Processing of potatoes to crisps, granules and wet and dried peels.

Table 56. Paraquat residues in potatoes and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
ID, 1988 (Russet Burbank)	2.8		31	1	B*	<0.05	Unwashed tuber from field	Roper 1989b 16ID88-400
						<0.025	Washed tuber	
						<0.05	Wet peels	
						<0.125	Dry peels	
						<0.025	Peeled potatoes	
						<0.025	Crisps	
						<0.05	Granules	
					7	<0.05	Unwashed ber from field	
						0.05	Washed tuber	
						0.13	Wet peels	
						0.45	Dry peels	
						<0.025	Peeled potatoes	
						0.05	Crisps	
						0.15	Granules	
ME, 1988 (Superior)	2.8		31	1	B*	<0.05	Unwashed tuber from field	56ME88-401
						<0.025	Washed tuber	
						<0.05	Wet peels	
						<0.125	Dry peels	
						<0.025	Peeled potatoes	
						<0.025	Crisps	
						<0.05	Granules	
					7	0.11	Unwashed tuber from field	
						0.10	Washed tuber	
						0.13	Wet peels	
						1.3	Dry peels	
						0.03	Peeled potatoes	
						0.10	Crisps	
						0.26	Granules	

B*=control.

Processing factors calculated are shown in Table 57.

Table 57. Processing factors for processed products of potatoes.

Product	16ID88-400		56ME88-401	
	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
Whole unwashed tuber from field	<0.05	-	0.11	
Whole washed tuber from processor	0.05	>1	0.10	0.91
Wet peel	0.13	>2.6	0.13	1.2
Dry peel	0.45	>9	1.3	12
Peeled potato	<0.025	-	0.03	0.27
Crisps	0.05	>1	0.1	0.09
Granules	0.15	>3	0.26	2.4

Processing of maize

A study was conducted in Iowa, USA, in 1988 to determine paraquat residues in crude and refined oils and milled fractions from maize treated with one broadcast application (harvest aid use) of paraquat at a rate of 2.8 kg ai/ha and harvested 7 days after the application. Maize grains (kernels) were processed as shown in Figure 13. The results of residue analysis are shown in Table 58. The limit of quantification was 0.05 mg/kg for all samples (Roper, 1989g).

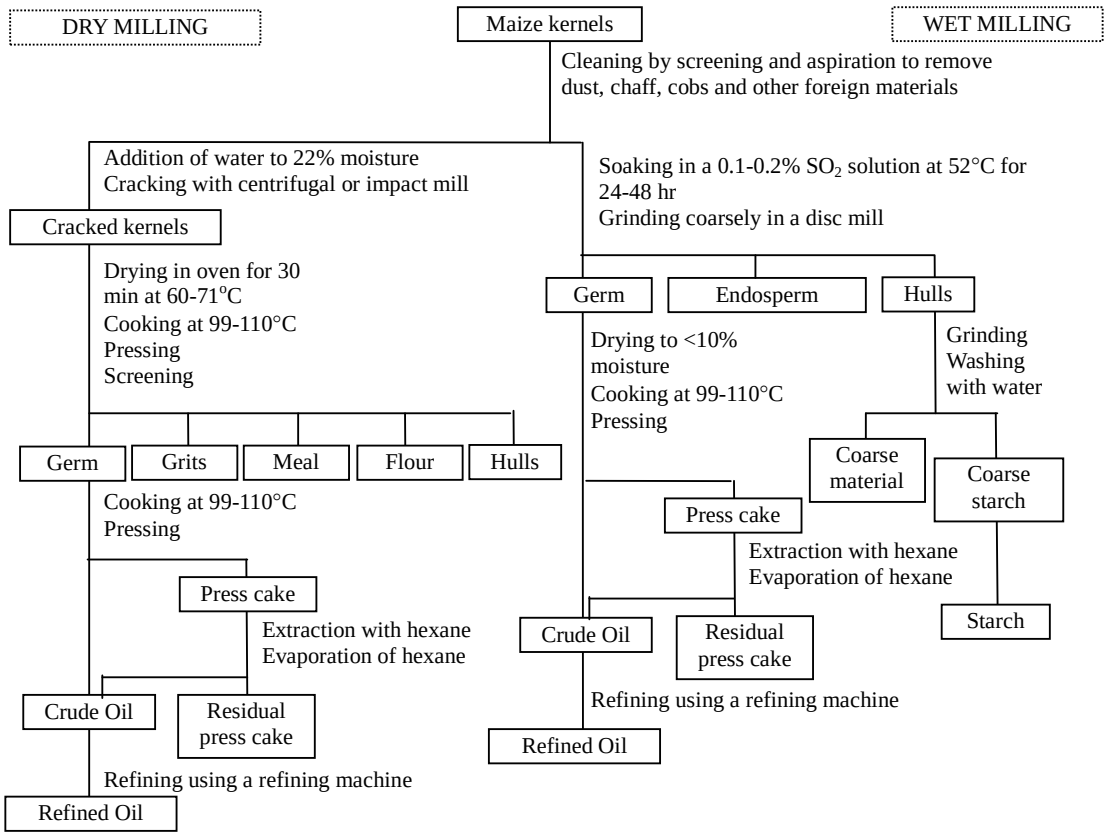


Figure 13. Processing of maize to oil, starch and milling fractions.

Table 58. Paraquat residues in maize and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	References
	kg ai/ha	kg ai/hl	water, l/ha	No.				
IA, 1988 (Pioneer 3471)	2.8		31	1	B*	<0.05	All the uncontrolled samples	Roper 1989g
					7	0.4	Kernels from field	36IA88-791
							DRY MILLING	
						0.2	Kernels from processor	
						0.05	Large grits	
						0.09	Medium grits	
						0.1	Small grits	
						0.2	Coarse meal	
						0.1	Meal	
						0.3	Flour	
						1	Hulls	
						0.06	Germ	
						0.1	Expeller press cake	
						0.1	Extraction press cake	
							Expeller crude oil	
						<0.05	Refined oil	
						<0.01	WET MILLING	
						0.2	Kernels from processor	
							Hulls	
						<0.05	Germ	
						<0.05	Course starch	
						<0.05, 0.05	Starch	
						<0.05	Expeller press cake	
						0.06	Extraction press cake	
						<0.05	Expeller crude oil	
							Refined oil	
						<0.05		
						<0.05		

B*: control

Processing factors calculated are shown in Table 59. There was no detectable transfer to oil.

Table 59. Processing factors for maize products.

Product	Wet milling		Dry milling	
	Paraquat (mg/kg)	Processing Factor	Paraquat (mg/kg)	Processing Factor
Whole kernel from processor	0.2		0.2	
Hulls	<0.05	<0.25	1	5
Germ	<0.05	<0.25	0.06	0.3
Large grits			0.05	0.25
Medium grits			0.09	0.45
Small grits			0.1	0.5
Coarse meal			0.2	1
Meal			0.1	0.5
Flour			0.3	1.5
Coarse starch	<0.05	<0.25		
Starch	<0.05	<0.25		
Expeller press cake	0.06	0.30	0.1	0.5
Extraction press cake	<0.05	<0.25	0.1	0.5
Expeller Crude oil	<0.05	<0.25	<0.05	<0.25
Refined oil	<0.05	<0.25	<0.01	<0.05

Processing of sorghum

Studies were conducted in Texas, California and Nebraska, USA in 1973/1974 to determine paraquat residues in milling fractions of sorghum. Sorghum was treated with one aerial application as a post-emergence harvest aid at a rate of 0.21 kg ai/ha (Texas and California) or 0.43 ka ai/ha and harvested 7-24 days after treatment. Grain was processed to flour, bran and shorts (byproduct of milling consisting of bran, germ and course meal). The results of residue analysis are shown in Table 60 (Anon., 1975a).

In more recent studies in Texas and Nebraska in 1988 and 1989 sorghum was treated with one broadcast application as a post-emergence harvest aid at a rate of 2.8 kg ai/ha, equivalent to five times the normal rate permitted in the USA, and harvested 3 or 7 days after treatment. Whole sorghum grain was processed into hulled grain, wet and dry milled bran, coarse grits, starch, and flour by both dry and wet milling as indicated in Figure 14. The results of residue analysis are shown in Table 60. The limits of quantification were 1 mg/kg for whole grain and grits, 10 mg/kg for bran and 0.5 mg/kg for starch and flour (Roper, 1989j).

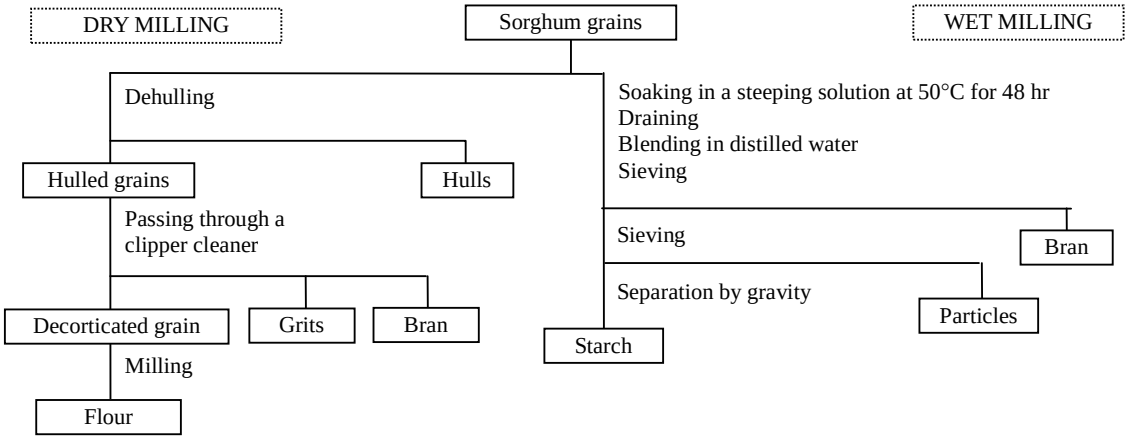


Figure 14. Processing of sorghum to hulled grains, bran, grits and flour.

Table 60. Paraquat residues in sorghum and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
TX, 1988 (Golden Acres T-E Y-75)	2.8				B*	<1	Grain, whole & hulled	Roper, 1989j 11TX88-793
							Coarse grits	
						<1	Bran	
						<10	Starch	
						<0.5	Flour	
						<0.5	Grain from field	
					3	12.5	Grain from processor	
						10.4	Dry milled bran	
							Coarse grits	
						69.7	Flour	
						3.3	Wet milled bran	
						3.6	Starch	
						44.8		
						1.4		

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
NE, 1989 (NK 2230)	2.8				B*	<1	Grain, whole & hulled	41NB88-794
							Grits	
						<1	Bran	
						<10	Starch	
						<0.5	Flour	
						<0.5	Grain from field	
					7	26.4	Grain from processor	
						9.2	Hulled grain	
							Dry milled bran	
						1.8	Coarse grits	
						51.6	Flour	
						2.2	Wet milled bran	
						2.5	Starch	
						23.8		
						0.7		
TX, 1970	0.21		7.7	1	7	0.61	Grain	Anon 1975a
						0.08	Flour	T-2004
						3.3	Bran	
						1.1	Shorts	
					24	0.33	Grain	
						0.07	Flour	
						1.4	Bran	
						0.53	Shorts	
CA, 1970	0.21		7.7	1	7	0.83	Grain	T-2005
						0.41	Flour	
					21	0.50	Grain	
						0.30	Flour	
NE, 1973	0.43		4.6	1	8	2.7	Grain	T-2779
						0.10	Flour	
						6.8	Bran	
						9.1	Shorts	
						1.4	Germ	

B*: control

Processing factors calculated are shown in Table 61.

Table 61. Processing factors for sorghum .

Product	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
	11TX88-793		41NB88-794	
Whole grain from field	12.5		26.4	
Whole grain from processor	10.4	0.83	9.2	0.35
Hulled grain			1.8	0.07
Dry milled bran	69.7	5.6	51.6	2.0
Coarse grits	3.3	0.26	2.2	0.08
Flour	3.6	0.29	2.5	0.09
Wet milled bran	44.8	3.6	23.8	0.90
Starch	1.4	0.11	0.7	0.03
	T-2004 (PHI: 7 days)		T-2779	
Grain	0.61		2.7	
Flour	0.08	0.13	0.10	0.04
Bran	3.3	5.4	6.8	2.5
Shorts	1.1	1.8	9.1	3.4
Germ			1.4	0.52

Processing of cotton

In a study Texas in 1964 cotton was treated once with paraquat as a harvest aid desiccant at a rate of 0.56 kg ai/ha, harvested 1-10 days after application, and processed. Processed fractions were analysed with the results shown in Table 62. The limit of quantification was 0.01 mg/kg (Chevron, 1966).

Another study was conducted in Texas, Arizona, Oklahoma and California to determine the paraquat residue levels of cotton gin trash. Mature cotton received one broadcast application of paraquat at a rate of 0.56 kg ai/ha as a harvest aid desiccant. In one site in Texas, cotton was treated by aerial application. Cotton bolls were harvested after 13 days (2 trials in California), 14 days (5 trials in Texas, Arizona and Oklahoma) and 17 days (2 trials in Texas). Cotton bolls were passed through a cotton gin and the gin trash collected for analysis. The residues in the gin trash were 32 and 34 mg/kg 13 days after treatment; 5.2, 7.3, 9.4, 11 and 12 mg/kg 14 days after treatment; 7.3 and 11 mg/kg from aerial application; and 5.9 and 6.2 mg/kg 17 days after treatment. However, no information on the paraquat levels in cotton was available for estimating processing factors.

A flow chart for cotton processing is shown in Figure 15.

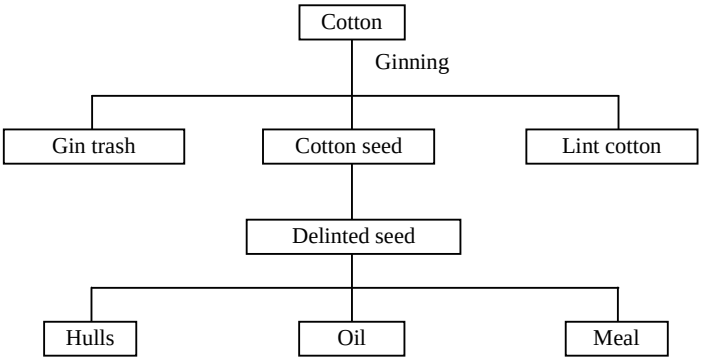


Figure 15. Flow chart for cotton processing.

Table 62. Paraquat residues in cotton and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
TX, 1964 (Blightmaster)	0.56			1	B*	<0.05		Chevron 1966 T-653
					10	2.03	Cotton (including trash & bolls)	
						0.18	Fuzzy seed	
						0.05	Acid-delinted seed	
						0.08	Mechanically reginned seed	
						3.07	Lint cotton	
						0.13	Hulls	
						<0.01	Crude oil	
						0.02	Meal	

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
TX, 1964 (Rex)	0.56			1	9	1.37	Cotton (including trash & bolls)	T-654
						0.09	Fuzzy seed	
						<0.01	Acid-delinted seed	
						<0.01	Mechanically reginned seed	
						0.01	Hulls	
						<0.01	Crude oil	
						<0.01	Meal	
							BIS(METHYSULFATE) SALT**	
						1.13	Cotton (including trash & bolls)	
						0.14	Fuzzy seed	
						<0.01	Acid-delinted seed	
						0.01	Mechanically reginned seed	
						<0.01	Hulls	
						<0.01	Crude oil	
						<0.01	Meal	

B*: control ** dichloride salt used

Processing factors calculated are shown in Table 63.

Table 63. Processing factors for cotton products.

Product	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
	T-653		T-654	
Cotton (trash & bolls)	2.03		1.37	
Fuzzy seed	0.18	0.09	0.09	0.07
Acid delinted seed	0.05	0.02	<0.01	<0.007
Mechanically delinted seed	0.05	0.02	<0.01	<0.007
Lint cotton	3.07	1.5		
Hulls	0.13	0.06	0.01	0.007
Crude oil	<0.01	<0.005	<0.01	<0.007
Meal	0.02	0.01	<0.01	<0.007

Sunflower

A study was conducted in California, Iowa, Minnesota, Mississippi, North Dakota, South Dakota and Texas, USA, to determine paraquat residues in sunflower oil and meal prepared from sunflower seed. Sunflowers received one application of paraquat as a harvest aid desiccant at rates from 0.28 to 1.12 kg ai/ha (ground application in 5 of 16 tests and aerial application in the others). Mature seeds were harvested 1-3 weeks after treatment and processed to oil, meal and hulls. The results of residue analysis are given in Table 64. The LOQ was 0.01 mg/kg (Chevron, 1975a).

Table 64. Paraquat residues in sunflower products from trials in the USA.

Location , year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
CA, 1971 (Peredovik)	0.28		61	1	B*	<0.01		Chevron
					7	0.11	Mature seed	1975a
						0.25	Hulls	T-2185
						0.15	Meal	(ground appl.)
						<0.01	Oil	
	0.56		61			0.35	Mature seed	
						0.62	Hulls	
						0.55	Meal	
						<0.01	Oil	

Location , year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
MS, 1971 (NK-HO1)	0.28		7.5	1	7	0.21	Mature seed	T-2186 (ground appl.)
						1.9	Hulls	
						0.92	Meal	
						<0.01	Oil	
	0.56		7.5			0.31	Mature seed	
						3.4	Hulls	
						0.66	Meal	
						<0.01	Oil	
MN, 1972 (VNIIMK 8931)	0.28		7.7	1	7	0.08	Mature seed	T-2392 (aerial appl)
						0.08	Hulls	
						0.12	Meal	
						<0.01	Oil	
					14	0.11	Mature seed	
						0.09	Hulls	
						0.20	Meal	
						<0.01	Oil	
					21	0.12	Mature seed	
						0.08	Hulls	
						0.13	Meal	
						<0.01	Oil	
MN, 1972 (VNIIMK 8931)	0.28		7.7	1	7	0.06	Mature seed	T-2393 (aerial appl)
						0.06	Hulls	
						0.06	Meal	
						<0.01	Oil	
					14	0.04	Mature seed	
						0.05	Hulls	
						0.06	Meal	
						<0.01	Oil	
					21	0.03	Mature seed	
						0.02	Hulls	
						0.05	Meal	
						<0.01	Oil	
CA, 1972 (HO-1)	0.28		34	1	7	0.13	Mature seed	T-2394 (ground appl)
						0.15	Hulls	
						0.19	Meal	
						<0.01	Oil	
					14	0.10	Mature seed	
						0.13	Hulls	
						0.19	Meal	
						<0.01	Oil	
					21	0.11	Mature seed	
						0.10	Hulls	
						0.18	Meal	
						<0.01	Oil	
IA, 1973 (Peredovik)	0.56		31	1	7	0.12	Mature seed	T-2679 (ground appl.)
						0.31	Hulls	
						<0.01	Meal	
						<0.01	Oil	
	1.12		31			0.19	Mature seed	
						0.54	Hulls	
						0.01	Meal	
						<0.01	Oil	
ND, 1973 (Peredovik)	0.56		7.7	1	7	0.16	Mature seed	T-2680 (aerial appl.)
						0.57	Hulls	
						0.01	Meal	
						<0.01	Oil	
CA, 1973 (RHA-271)	0.56		34	1	7	0.09	Mature seed	T-2681 (ground appl.)
						0.27	Hulls	
						<0.01	Meal	
						<0.01	Oil	
MS, 1973 (HF-52)	0.56		7.7	1	7	0.13	Mature seed	T-2682 (aerial appl)
						0.38	Hulls	
						<0.01	Meal	
						<0.01	Oil	

Location , year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
SD, 1973 (Record)	0.63		3.8	1	14	0.16 0.46 0.02 <0.01	Mature seed Hulls Meal Oil	T2683 (aerial appl)
MN, 1973 (Cargill 101)	0.56		7.7	1	9	0.21 0.62 0.02 <0.01	Mature seed Hulls Meal Oil	T-2684 (aerial appl)
MN, 1974 (Sputnik)	0.56		7.7	1	7	0.14 0.28 0.09 <0.01	Mature seed Hulls Meal Oil	T-3069 (aerial appl)
ND, 1974 (Sputnik)	0.56		7.7	1	7	0.24 0.55 0.13 <0.01	Mature seed Hulls Meal Oil	T-3070 (aerial appl)
TX, 1974 (Sun Hi 372)	0.56		7.7	1	15	0.19 0.40 0.11 <0.01	Mature seed Hulls Meal Oil	T-3126 (aerial appl)

B*: control

Processing factors calculated from the results obtained with an application rate of 1.12 kg ai/ha are shown in Table 65.

Table 65. Processing factors from sunflower seed to processed commodities

Product	Paraquat (mg/kg)	Processing factor
	T-2679	
Mature seed	0.19	
Hulls	0.54	2.8
Meal	0.01	0.05
Oil	<0.01	<0.05

In some trials with lower application rates, higher paraquat residues (0.35, 0.31 and 0.24 mg/kg) were observed in mature seeds. However, the paraquat concentrations in the oil samples, prepared from these mature seeds with higher paraquat residues, were below the limit of detection of 0.01 mg/kg.

Hops

A study was conducted in the states of Idaho and Washington, USA, to determine paraquat residues in spent hops and a methylene chloride extract from dried hops. Hop vines were treated three times with a directed spray of paraquat at a rate of 2.8 kg ai/ha, five times the normal rate in the USA. Green hop cones were harvested 13 or 14 days after the last treatment. Bulk samples of green hops were dried according to commercial practice. Dried hops were processed into spent hops and methylene chloride extract as shown in Figure 16. The results of residue analysis are shown in Table 66. The limit of quantification was 0.05 mg/kg for green hops, 0.1 mg/kg for dried and spent hops, and 0.0125 mg/kg for methylene chloride extract (Roper, 1989).

Another study was conducted in Oregon, USA, to determine paraquat residues in beer. The hop vines received three applications except one trial in which only two applications were made, at 0.56, 1.12 or 2.24 kg ai/ha each time. Green cones were harvested 14 days after the last application. A portion of the cones were dried and used to make beer. No detailed description of beer brewing process was provided. The results of residue analysis are given in Table 67. The LOQ was 0.01 mg/kg for green hops, dried hops and beer (Anon., 1975).

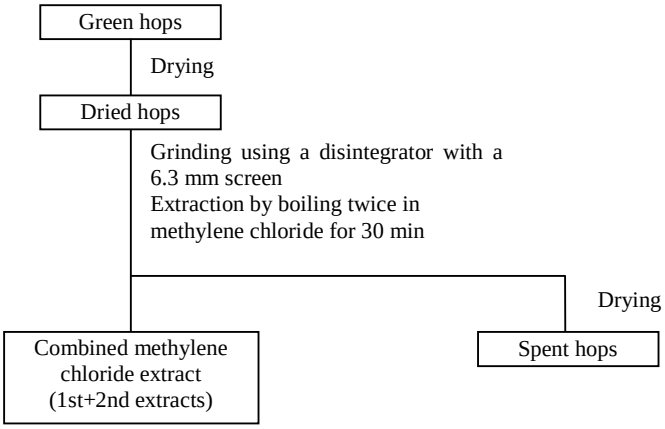


Figure 16. Processing of green hops to dried hops, spent hops and methylene chloride extract of hops.

Table 66. Paraquat residues in hops and processed products from trials in the USA.

Location, year (variety)	Application				PHI days	Paraquat mg/kg	Notes	Reference
	kg ai/ha	kg ai/hl	water, l/ha	No.				
ID, USA, 1988 (Hallertau Mittelfrueh)	2.8		31	3	B*	<0.05	Green hops	Roper 1989d 15ID88-591
						<0.1 (0.04)	Dried hops	
						<0.1 (0.05)	Spent hops	
						<0.0125	Mehylene chloride extract	
					14	<0.05 (0.04)	Green hops	
						<0.1 (0.06)	Dried hops	
						<0.1 (0.06)	Spent hops	
						<0.0125	Mehylene chloride extract	
WA, USA, 1988 (L-1 Clusters)	2.8		31	3	B*	<0.05	Green hops	15WA88-592
						<0.1	Dried hops	
						<0.1 (0.04)	Spent hops	
						<0.0125	Mehylene chloride extract	
					13	<0.05 (0.02)	Green hops	
						<0.1 (0.06)	Dried hops	
						<0.1 (0.03)	Spent hops	
						<0.0125	Mehylene chloride extract	
OR, USA, 1973 (Cascade)					B*	<0.01	Green hops	Anon. 1975b T-2639
						<0.01	Dried hops	
						<0.01	Beer	
	0.56			3	14	0.04	Green hops	
						0.05	Dried hops	
						0.01	Beer	
	1.12			3	14	0.05	Green hops	
						0.01	Dried hops	
						<0.01	Beer	
OR, USA, 1973	1.12			2	14	0.03	Green hops	T-2640
						0.03	Dried hops	
						<0.01	Beer	
	2.24			2	14	0.01	Green hops	
						0.02	Dried hops	
						<0.01	Beer	
OR, USA, 1973	0.56			3	14	0.04	Green hops	T-2958
						0.05	Dried hops	
						<0.01	Beer	
	1.12			3	14	0.03	Green hops	
						0.07	Dried hops	
						<0.01	Beer	

B*: control

In the study on processing green hops to dried hops, spent hops and methylene chloride extract, residues were all below the limit of quantification, so processing factors could not be reliably calculated. Processing factors were calculated for brewing beer and are shown in Table 67. Drying green hops to dried hops does not cause much increase in the concentration of paraquat which indicates some degradation of paraquat during drying.

Table 67. Processing factors from green hops to hops and beer.

Product	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor	Paraquat (mg/kg)	Processing factor
	T-2639 (0.56 kg ai/ha)		T-2958 (0.56 kg ai/ha)		T-2639 (1.12 kg ai/ha)	
Green cones	0.04		0.04		0.05	
Dry cones	0.05	1.3	0.05	1.3	0.01	0.2
Beer	0.01	0.25	<0.01	<0.25	<0.01	<0.2
	T-2958 (1.12 kg ai/ha)		T-2640 (1.12 kg ai/ha)		Mean processing factor	
Green cones	0.03		0.03			
Dry cones	0.07	2.3	0.03	1	1.2	
Beer	<0.01	<0.33	<0.01	<0.33	<0.28	

Maximum application rate in the USA: 0.55 kg ai/ha.

RESIDUES IN ANIMAL COMMODITIES

Farm animal feeding studies

In animal metabolism studies on a goat and hens, paraquat residue concentrations were measured in tissues, milk and eggs (see Tables 7-9). No additional animal feeding studies were submitted.

RESIDUES IN FOOD IN COMMERCE OR AT CONSUMPTION

In the residue monitoring data from the Australian National Residue Survey (2001-2002), 18 samples of macademia nuts were analysed for paraquat by an HPLC method. No residues were detected above the limit of reporting of 0.02 mg/kg.

NATIONAL MAXIMUM RESIDUE LIMITS

National MRLs in Argentina, Brazil, Czech Republic, European Union, Peru and the USA were reported by the manufacturer. The information on MRLs in Japan was obtained from the official web site of the Ministry of Environment. The information on MRLs in Australia and tolerances in the USA was provided by the governments of Australia and the USA respectively.

Table 68. National maximum residue limits.

Country	**Commodity**	**MRL (mg/kg)**
Argentina	Cotton oil	0.05
	Cotton seed	0.2
	Potato	0.2
Australia	Cereal grains [except maize; rice]	0.05*
	Cotton seed	0.2
	Cotton seed oil, edible	0.05
	Edible offal (mammalian)	0.5
	Eggs	0.01*
	Fruits (except olives)	0.05*
	Hops, dry	0.2
	Maize	0.1
	Meat (mammalian)	0.05*
	Milks	0.01*
	Olives	1
	Peanut	0.01*
	Peanut, whole	0.01*
	Potato	0.2
	Poultry, Edible offal of	0.05*
	Poultry meat	0.05*
	Pulses	1
	Rice	10
	Rice, polished	0.5
	Sugar cane	0.05*

Country	Commodity	MRL (mg/kg)
	Tree nuts	0.05*
	Vegetables (except potato; pulses)	0.05*
Brazil	Banana	0.05
	Corn	0.1
	Cotton	0.2
	Fruits (various)	0.05
	Grapes	0.05
	Potato	0.2
	Rice	0.5
	Sorghum	0.5
	Soya bean	0.1
	Vegetables (various)	0.05
	Wheat	0.01
Czech R.	Hop, Dried	0.2
European Union	Fruits (various; including tree fruits, vine and strawberries)	0.05
	Hops, dry	0.1
	Oilseeds (various)	0.05
	Tea	0.1
	Tree nuts (various)	0.05
	Vegetables (various; including some herbs)	0.05
Japan (withholding limits)	Asparagus	0.05
	Barley	0.05
	Broccoli	0.05
	Burdock	0.05
	Cabbage	0.05
	Carrot	0.05
	Cauliflower	0.05
	Cucumber	0.05
	Eggplant	0.05
	Fruits (of any fruit tree)	0.05
	Japanese radish	0.05
	Konjac	0.05
	Lettuce	0.05
	Melons	0.05
	Oat	0.05
	Onion, bulb	0.05
	Peppers, sweet	0.05
	Potato	0.05
	Pumpkin	0.05
	Rice, hulled	0.1
	Rye	0.05
	Spinach	0.05
	Strawberry	0.05
	Sweet potato	0.05
	Tomato	0.05
	Watermelon	0.05
	Welsh onion	0.05
	Wheat	0.05
	Yam	0.05
Peru	Banana	0.05
	Cocoa	0.5
	Coffee	0.05
	Grape	0.05
	Oil palm	0.05
	Orange	0.05
	Potato	0.05
	Rice	0.05

Country	Commodity	MRL (mg/kg)
	Sugar cane	0.5
	Tea	0.05
USA	Acerola	0.05
	Alfalfa	5
	Almond, hulls	0.5
	Apple	0.05
	Apricot	0.05
	Artichoke, globe	0.05
	Asparagus	0.5
	Avocado	0.05
	Banana	0.05
	Barley, grain	0.05
	Bean, dry, seed	0.3
	Bean, forage	0.1
	Bean, hay	0.4
	Bean, lima, succulent	0.05
	Bean, snap, succulent	0.05
	Beet, sugar	0.5
	Beet, sugar, tops	0.5
	Birdsfoot trefoil	5
	Broccoli	0.05
	Cabbage	0.05
	Cabbage, Chinese	0.05
	Cacao bean	0.05
	Carrot, roots	0.05
	Cattle, fat	0.05
	Cattle, kidney	0.3
	Cattle, meat	0.05
	Cattle, meat byproducts, except kidney	0.05
	Cauliflower	0.05
	Cherry	0.05
	Clover	5
	Coffee bean	0.05
	Collards	0.05
	Corn, field, forage	3.0
	Corn, field, grain	0.1
	Corn, field, stover	10.0
	Corn, fresh (inc sweet corn), kernel plus cob with husks removed	0.05
	Corn, pop, grain	0.1
	Corn, pop, stover	10.0
	Cotton, undelinted seed	0.5
	Cucurbits	0.05
	Egg	0.01
	Endive	0.05
	Fig	0.05
	Fruit, citrus	0.05
	Goat, fat	0.05
	Goat, kidney	0.3
	Goat, meat	0.05
	Goat, meat byproducts, except kidney	0.05
	Grass, pasture	5
	Grass, range	5
	Guar bean	0.5
	Guava	0.05
	Hog, fat	0.05
	Hog, kidney	0.3
	Hog, meat	0.05

Country	Commodity	MRL (mg/kg)
	Hog, meat byproducts, except kidney	0.05
	Hop, dried cone	0.2
	Horse, fat	0.05
	Horse, kidney	0.3
	Horse, meat	0.05
	Horse, meat byproducts, except kidney	0.05
	Kiwifruit	0.05
	Lentil, seed	0.3
	Lettuce	0.05
	Milk	0.01
	Mint, hay	0.5
	Mint, hay, spent	3.0
	Nectarine	0.05
	Nut	0.05
	Olive	0.05
	Onion, dry bulb	0.05
	Onion, green	0.05
	Papaya	0.05
	Passionfruit	0.2
	Pea, dry, seed	0.3
	Peach	0.05
	Peanut	0.05
	Peanut, hay	0.5
	Pear	0.05
	Pea (succulent)	0.05
	Pea, field vines	0.2
	Pea, field, hay	0.8

Country	Commodity	MRL (mg/kg)
	Persimmon	0.05
	Pineapple	0.05
	Pistachio	0.05
	Plum, prune, fresh	0.05
	Potato	0.5
	Rhubarb	0.05
	Rice, grain	0.05
	Rice, straw	0.06
	Safflower, seed	0.05
	Sheep, fat	0.05
	Sheep, kidney	0.3
	Sheep, meat	0.05
	Sheep, meat byproducts, except kidney	0.05
	Small fruit	0.05
	Sorghum, forage	0.05
	Sorghum, grain	0.05
	Soybean	0.05
	Soybean forage	0.05
	Strawberry	0.25
	Sugarcane, cane	0.5
	Sunflower, seed	2
	Turnip, greens	0.05
	Turnip, roots	0.05
	Vegetable, fruiting	0.05
	Wheat	0.05

APPRAISAL

Paraquat, a non-selective contact herbicide, was first evaluated by the JMPR for toxicology and residues in 1970. Subsequently, it was reviewed for toxicology in 1972, 1976, 1982, 1985 and 1986 and for residues in 1972, 1976, 1978 and 1981. The Meeting reviewed paraquat toxicologically within the periodic review programme in 2003 and established an ADI of 0–0.005 mg/kg bw and an ARfD of 0.006 mg/kg bw as paraquat cation. Currently, there are 22 Codex MRLs for plant commodities, their derived products and animal commodities.

The CCPR at its Thirty-second Session identified paraquat as a priority for periodic review by the 2002 JMPR, but residue evaluation was postponed to the present Meeting.

Paraquat is usually available in the form of paraquat dichloride or paraquat bis(methylsulfate). The Meeting received data on metabolism, environmental fate, analytical methods, storage stability, supervised field trials, processing and use patterns.

Metabolism

Animals

The WHO Expert Group of the 2003 JMPR reviewed studies on the the excretion balance of paraquat in *rats* given a single dose of 1 or 50 mg/kg bw [1,1´-^{14}C-dimethyl]paraquat dichloride or 14 daily doses of 1 mg/kg bw unlabelled paraquat dichloride followed by 1 mg/kg bw of the labelled compound. They also evaluated studies of the biotransformation of paraquat in rats given the same doses of radiolabelled paraquat and other studies of metabolism and toxicity in rats. They concluded that orally administered paraquat is not well absorbed. Excretion was rapid, with 60–70% in faeces and 10–20% in urine; 90% was excreted within 72 h. Paraquat was eliminated largely unchanged: 90–95% of radiolabelled paraquat in urine was identified as the parent compound.

When 23 mg/kg [1,1´-^{14}C-dimethyl]paraquat dichloride were administered through a rumen fistula to one *sheep*, all the administered radiolabel was excreted within 10 days in urine (4%) and faeces (96%), indicating that residues of orally administered paraquat would not remain or accumulate in sheep tissues. Most of the radiolabel in urine and faeces was attributed to unchanged paraquat and 2–3% to paraquat monopyridone. Less than 1% 4-carboxy-1-methylpyridinium ion, paraquat dipyridone and monoquat were found.

When 0.92 mg/kg [1,1´-^{14}C-dimethyl]paraquat dichloride was administered subcutaneously to a sheep, paraquat was again excreted rapidly. Over 80% of the administered radioactivity was excreted in urine, 69% 1 day after treatment. Unchanged paraquat accounted for most of the radiolabel. The monopyridone was present at 2–3% and monoquat as a trace metabolite. The excretion patterns in the two sheep were virtually identical, regardless of the route of administration.

A *pig* weighing about 40 kg was fed twice daily with a diet containing [1,1´-^{14}C-dimethyl]paraquat ion at a rate equivalent to 50 mg/kg for 7 days. At sacrifice, 69% of the administered radiolabel had been excreted in faeces and 3.4% in urine; 13% was present in the stomach contents and viscera. All the radiolabel found in tissues, except in liver, was attributed to paraquat. About 70% of the radiolabel in the liver was identified as paraquat, with 7% as monoquat ion and about 0.6% as monopyridone ion. This result indicates that there is no significant metabolism of paraquat in pigs.

In a similar study, a pig was fed a diet containing [2,2´,6,6´-^{14}C]paraquat ion at a rate equivalent to 50 mg/kg for 7 days. At sacrifice, 72.5% of the administered radiolabel had been excreted in faeces and 2.8% in urine. In the liver, about 70% of the radiolabel was identified as paraquat and 4% as monoquat ion.

A Friesian *cow* weighing 475 kg given a single dose of about 8 mg/kg [1,1´-^{14}C-dimethyl]paraquat dichloride from a balling gun excreted 95.6% of the administered radioactivity in faeces within 9 days; 89% was excreted within the first 3 days. Analysis indicated that 97–99% of the radioactivity in 1–4-day faeces and 100% of that in 5–6-day faeces co-chromatographed

with paraquat. A total of 0.7% of the administered dose was excreted in urine, 80% of which was excreted within the first 2 days. Paraquat accounted for 90% of the radiolabel in urine on day 1, 70% on day 3 and 62% on day 5. The remaining activity was attributed to paraquat monopyridone and monoquat. Only 0.0032% of the administered radiolabel was recovered from milk within 9 days. The traces of radioactivity in milk (a maximum of 0.005 mg/l as paraquat ion equivalent milk taken in the morning of day 2) were attributed mainly to paraquat and its monopyridone and to a naturally occurring compound which appeared to be lactose. The residue level of any one compound in milk was ≤ 0.002 mg/kg.

When a lactating *goat* was dosed with [2,2´,6,6´-^{14}C]paraquat dichloride twice daily at each milking for 7 days at a total daily rate equivalent to approximately 100 mg/kg in the diet, 50.3% of the administered radioactivity was excreted in faeces, 2.4% in urine and 33.2% in stomach contents by the time of sacrifice. The total radioactivity, expressed in paraquat ion equivalents, in milk increased during the experimental period, reaching a maximum of 0.0092 mg/kg (equivalent to 0.003% of the daily dose) 4 h before slaughter. Of this radioactivity, 75.7% was attributed to paraquat, and 15.8% did not show a cationic character. There appeared to be no significant metabolism of paraquat in any tissue, except liver and peritoneal fat, where about half the radiolabel was attributed to paraquat, < 5% as monopyridone ion and 5% as monoquat ion.

Warren laying *hens* given [2,2´,6,6´-^{14}C]paraquat ion in gelatin capsules at a rate equivalent to 30 mg/kg normal diet for 10 days had excreted 99% of the administered radiolabel in faeces at the time of sacrifice; 96.6% of the radiolabel was attributed to unchanged paraquat. The amount of radiolabel in egg albumen did not exceed 0.0014 mg/kg in paraquat ion equivalents throughout the experimental period, while that in the yolk was < 0.001 mg/kg on day 1 and increased gradually to 0.18 mg/kg (in one bird) on day 8. All the radiolabel in yolk was identified as paraquat.

The studies on the fate of orally administered paraquat show that most is excreted unchanged, mainly in faeces and to a much smaller extent in urine. Excretion of paraquat was rapid in all the species studied, hens showing the most efficient excretion. Little paraquat was absorbed from the gastrointestinal tract, and the small amount absorbed was not significantly metabolized. Less than 0.05 mg/kg of paraquat was found in muscle, milk and eggs, even at the high dose rates used in these studies. These findings indicate that no significant bioaccumulation of paraquat is expected to occur in these species.

The metabolism of paraquat in these species was similar. Four metabolites were identified: monoquat, paraquat monopyridone, 4-carboxy-1-methylpyridinium ion and paraquat dipyridone. In all tissues except liver of all the species tested and in goat peritoneal fat, 80–100% of the total radiolabel was attributable to the parent compound, paraquat. In liver and goat peritoneal fat, 50–80% of the radiolabel was associated with paraquat, and absorbed paraquat was metabolized to monoquat and paraquat monopyridone and to a much smaller extent to 4-carboxy-1-methylpyridinium ion. The metabolism of paraquat involves oxygenation of one pyridine ring to form paraquat monopyridone and desmethylation of one pyridine ring to form monoquat. Cleavage of the pyridine–pyridine linkage produces 4-carboxy-1-methylpyridinium ion. The other *N*-methylpyridine moiety would produce carbon dioxide and methylamine.

Plants

When paraquat is used as a directed spray before sowing, before planting, before emergence and after emergence, it is present in soil as residues, but no direct contact occurs with crops. Sandy loam soil in pots in which *lettuce* and *carrots* were sown was sprayed with [U-^{14}C-bipyridyl]paraquat ion immediately after sowing at rates equivalent to 14.3 kg ai/ha for lettuce and 14.7 kg ai/ha for carrots, which are 13 times the highest current application rates for those crops, and maintained in a greenhouse. The radiolabel in mature lettuce and carrots harvested 65 and 96 days after treatment represented 0.0034 and 0.0048 mg/kg in paraquat ion equivalents, respectively. This result confirms the lack of significant translocation of residues of paraquat from treated soil to lettuce leaves or carrot roots.

Paraquat is also used as a crop desiccant and harvest aid, when it is in direct contact with crops. The foliage of *potatoes* and *soya beans* growing in pots in a greenhouse was treated with ^{14}C-paraquat at

rates equivalent to 8.7 or 8.8 kg ai/ha (potato) and 8.2 kg ai/ha (soya beans), 14–16 times the highest current use for desiccation on potato and soya beans. The average TRR, expressed in paraquat ion equivalents, in soya and potato plants harvested 4 days after treatment were 638 mg/kg in soya foliage, 0.747 mg/kg in soya beans and 0.082 mg/kg in potato tuber. In all the samples, 89–94% of the TRR was identified as paraquat. The rest of the radioactive residue consisted of two or three fractions, none of which exceeded 10% of the respective TRR. In soya foliage extracts, small amounts of 4-carboxy-1-methylpyridinium ion (0.3% TRR) and monoquat (0.3 % TRR) were found. The latter is a known photodegradation product of paraquat.

As paraquat is strongly adsorbed by soil (see above), its uptake by plants after pre-emergence or post-emergence directed use is insignificant, even at exaggerated application rates. When paraquat was applied as a desiccant to potato and soya bean at a rate > 10 times the highest recommended application rate, with a 4-day PHI, the main component in potato tuber, soya beans and soya foliage was paraquat. In soya foliage, monoquat and 4-carboxy-1-methylpyridinium ion were also found. Although the latter is a known photodegradation product and was not found in soya beans or potato tuber, biotransformation cannot be excluded because the TRR was too low for reliable identification. As the fate of paraquat in soya foliage appears to involve photodegradation, its fate is considered to be common among plants.

The metabolism of paraquat involves desmethylation of one pyridine ring to form monoquat. 4-Carboxy-1-methylpyridinium ion appears to be produced by photolysis of monoquat, with breakdown of the pyridine–pyridine linkage, but involvement of biotransformation cannot be excluded. Paraquat monopyridone and dipyridone, which are found in animals, were not found in plants even at much higher than normal application rates. The transformation of paraquat in plants is similar to its metabolism in animals.

Environmental fate

Soil

Paraquat was applied to slurries of loam, loamy sand, silty clay loam or coarse sand in 0.01 mol/l aqueous calcium chloride at rates higher than normal, to give 0.01 mg/l in the equilibrium solution after a 16-h equilibration. The calculated adsorption coefficients ranged from 480 in the coarse sand to 50 000 in the loam. At normal application rates, the concentration of paraquat in the equilibrium solution could not be determined (< 0.0075 mg/l). No significant desorption was observed.

A field survey of 242 agricultural soils in Denmark, Germany, Greece, Italy, The Netherlands and the United Kingdom showed that paraquat was strongly adsorbed to all the soil types studied. The adsorption coefficients calculated at application rates much higher than normal ranged from 980 to 400 000, and those adjusted for the organic carbon content of soil were 8400–40 000 000. Adsorption coefficients could not be calculated at normal application rates because the concentration in equilibrium solution was below the limit of determination (0.01 mg/l). On the McCall scale, paraquat was classified as ‘immobile’ in all these soils, without leaching.

[2,6-^{14}C]Paraquat was applied to sandy loam soil in pots at a nominal rate of 1.05 kg/ha and incubated in the dark at 20 ± 2 °C under aerobic conditions in order to study the aerobic degradation of paraquat. After 180 days of incubation, paraquat accounted for > 93% of the applied radiocarbon, with no detected degradation products. Less than 0.1% of the applied radioactivity evolved as $^{14}CO_2$ over the 180-day incubation period. The half-life of paraquat in soil under aerobic conditions could not be estimated, although a long half-life in soil was implied by the results of the study.

In long-term field dissipation studies conducted on cropped plots in Australia, Malaysia, The Netherlands, Thailand, the United Kingdom and the USA, the location had no major effect on the field dissipation rate. Generally, paraquat residue levels had declined to about 50% 10–20 years after the start of the studies. This implies a DT_{50} of 10–20 years after application of single, large doses of paraquat to soil. The DT_{90} could not be estimated in these studies, however, as the experimental periods were too short.

Conventional laboratory studies could not provide useful information on the route or rate of degradation of paraquat in soil because of its strong adsorption to soil minerals and organic matter. In

order to obtain information, microbiological degradation studies were conducted with microorganisms isolated from soil. The most effective soil organism for decomposing paraquat was a yeast species, *Lipomyces starkeyi*. When incubated with radiolabelled paraquat, the yeast culture or cultures originating from two sandy loam soils decomposed most of the paraquat, released CO_2 and formed oxalic acid at 24–25 °C.

An unidentified bacterium isolated from soil metabolized [1,1´-^{14}C]paraquat to monoquat and 4-carboxy-1-methylpyridinium ion. Extracts of *Achromobacter* D were found to produce CO_2, methylamine, succinate and formate as metabolites of 4-carboxy-1-methylpyridinium ion. The results showed that the CO_2 originated from a carboxyl group, methylamine from the *N*-methyl group and the carbon skeletons of formate and succinate from the C-2 and C-3–C-6 atoms of the pyridine ring, respectively. These results indicate that the pyridine ring is split between C-2 and C-3.

The degradation rate of paraquat in soil was determined by cultivating 10 mg/kg [U-^{14}C-dipyridyl]paraquat with *Lipomyces* and mixed cultures derived from two soils. The degradation of paraquat was rapid, with a DT_{50} between 0.02 and 1.3 days after a lag phase of about 2 days, accompanied by rapid mineralization to CO_2 and the formation of several unidentified minor polar metabolites.

The photolysis of [2,2´,6,6´-^{14}C]-paraquat was studied by applying it to the surface of a highly sandy soil which was exposed to natural sunlight. The proportion of paraquat in samples declined during 85 weeks, at which time paraquat represented 86.6–89.5% of the total radiolabel found in unmixed and mixed soil samples. Thin-layer chromatographic analysis of the 6 mol/l HCl extracts of mixed and unmixed soils contained monoquat ion, paraquat monopyridone ion and an uncharacterized compound, which accounted for 1.4–2.4%, 1.2–1.3% and 1.8–2.4%, respectively, of the total radioactivity after 85 weeks. Photodegradation on the soil surface is not considered to be a major environmental degradation process for paraquat.

Water–sediment systems

Aqueous photolysis of paraquat was examined by maintaining ring-labelled paraquat in sterilized 0.01 mol/l phosphate buffer solution (28 mg/l) at 25 °C under light. After 36 days of irradiation simulating summer sunlight in Florida (USA), most of the recovered radioactivity was attributed to paraquat, with 0.13% as CO_2 and no photodegradation products. When solutions of radiolabelled paraquat were exposed to unfiltered ultraviolet light, no paraquat remained after 3 days, with formation of CO_2, methylamine and 4-carboxy-1-methylpyridinium ion; the last metabolite further degraded to CO_2 and methylamine. These results indicate that, while paraquat appears to be stable to photolysis at pH 7, it readily degrades into CO_2 and methylamine when exposed to unfiltered ultraviolet light.

[U-^{14}C-dipyridyl]Paraquat in deionized water was applied to the water surface of two continuously aerated sediment–water systems at a rate equivalent to 1.1 kg ai/ha. Paraquat was strongly adsorbed to the sediment in both systems, even immediately after treatment. After 100 days of incubation, 0.1–0.2% of the applied radioactivity was found in the aqueous phase, 92.9–94.9% in extracts from sediment fractions and 4.2–4.5% in unextracted sediment fractions. Most of the radiolabel recovered from the aqueous phase and sediment extract was attributed to paraquat, while no degradation products were detected. The DT_{50} or the DT_{90} could not be estimated as no significant degradation of paraquat was observed during the experimental period.

Residues in succeeding crops

Seeds of wheat, lettuce and carrot were sown into individual pots containing a sandy loam soil 0, 30, 120 and 360 days after treatment of the soil with [2,2´,6,6´-^{14}C]paraquat at an application rate equivalent to 1.05 kg ai/ha, and were maintained in a glasshouse until maturity. Over the course of the study, the TRR in soil represented an average of 99.2% of the applied radioactivity. ^{14}C-Paraquat accounted for 72.7–99.3% of the TRR in soil extracts and no other radioactive compounds were detected in any soil sample. Radioactive residues, expressed in paraquat ion equivalents per kilogram, were below the LOQ in most crop samples sown 0, 30 and 120 days after treatment. The highest

radioactive residue level, 0.009 mg/kg in paraquat ion equivalents, was found in wheat straw sown 30 days after treatment.

Seeds of lettuce and carrot were sown in pots containing sandy loam soil, and the soil was treated immediately afterwards with [U-^{14}C-dipyridyl]paraquat at exaggerated rates of 14.3 and 14.7 kg/ha respectively, corresponding to approximately 13 times the highest current application rate. The lettuce was harvested 65 days after treatment and the carrots 96 days after treatment. The levels of radioactive residues in lettuce leaf and carrot root at harvest were 0.0034 and 0.0048 mg/kg in paraquat ion equivalents, respectively. There is therefore no significant uptake of paraquat into rotational crops, even when the soil is treated at exaggerated rates.

Methods of analysis

With the long history of registration of paraquat in many countries, many analytical methods have been developed and used for measuring residues in plant and animal commodities. All the methods provided to the Meeting were for analysis of paraquat only. Some analytical methods allow separate determination of paraquat and diquat in a sample.

Samples of plant origin

Six analytical methods for the determination of paraquat in plant commodities and oil and oil cake were submitted.

Three of the methods involve extraction of paraquat by refluxing homogenized or comminuted samples in 0.5 mol/l sulfuric acid for 5 h; filtration, cation-exchange chromatography from which paraquat is eluted with saturated ammonium chloride, conversion of paraquat to its coloured free radical with 0.2% (w/v) sodium dithionite in 0.3 mol/l NaOH and spectrophotometric measurement. The methods differ only in the spectrophotometric measures used: absorption of the free radical in the range 360–430 nm measured against a control solution or absorption in the range of 380–430 nm measured in second derivative mode against a paraquat standard.

In the most recent method, the eluate from cation-exchange chromatography is further cleaned up on a C18 SepPak solid phase extraction cartridge, and the second 5-ml eluate is analysed by reverse-phase ion-pair HPLC with ultraviolet detection at 258 nm.

Two other methods developed for the determination of paraquat in liquid samples, such as oil, also involve second derivative spectrophotometry (360–430 nm), but they do not involve extraction with sulfuric acid. Reverse-phase ion-pair HPLC is also used as the confirmatory method.

All these methods were validated in one or several laboratories for vegetables and fruits, cereal grains and seed, grass and straw, sugar-cane juice, oil seeds, oil and oil cake. The LOQ of these methods ranged from 0.01 to 0.05 mg/kg, except for oil cake, for which the LOQ was 0.5 mg/kg. The mean procedural recoveries were 61–107% at fortification rates reflecting both the LOQ and the actual levels of incurred residues. In general, lower recoveries were made from oil and oil cake. The mean recovery from rape-seed oil cake and olive oil was 67% and that from coffee beans was 61%; those from other commodities were > 70%. The relative standard deviation of recoveries ranged from 2% to 19%.

Samples of animal origin

Three analytical methods for the determination of paraquat in animal products were submitted.

Two methods, including the most recent, for determining paraquat in milk, eggs and animal tissues involve extraction of paraquat by homogenizing samples in 10% trichloroacetic acid, centrifugation, dilution with water, application to a cation-exchange column, sequential washing, elution of paraquat with saturated ammonium chloride, determination by reverse-phase ion-pair HPLC with ultraviolet detection at 258 nm. Fat in milk, skin with subcutaneous fat and fat samples must be removed by hexane extraction before cation exchange.

A method for analysing liquid samples, including milk, does not involve acid extraction or defatting, and milk is mixed directly with cation exchange resin before packing. Otherwise, this method is the same as those described above.

The LOQs were reported to be 0.005 mg/kg for milk, eggs and bovine, ovine and chicken tissues. The mean procedural recoveries were 75–105%, with a relative standard deviation of 2–13%.

The currently used methods for plant and animal samples were found to be suitable for quantification of paraquat in plant and animal commodities for enforcement purposes. The methods are fully validated and include confirmatory techniques. The earlier methods for quantification of paraquat in plant and animal samples were also found to be suitable in validation; however, a mean recovery < 70% was seen for rape-seed cake, olive oil and coffee beans analysed by one of the methods.

Stability of residues in stored analytical samples

Investigations were reported of the stability of residues in ground samples of prunes, banana, cabbage, potato, carrot, tomato, maize (grain, forage, fodder and silage), wheat grain, coffee beans, birdsfoot trefoil (forage and hay), meat, milk and eggs stored in a deep freezer at a temperature < –15 °C for 1–4 years.

No decrease in residue levels of paraquat, whether fortified or incurred, was observed in any of the crop matrices during the test period, the longest being 46 months. The exception was a slight decrease in birdsfoot trefoil forage that had been treated at a rate equivalent to 0.54 kg ai/ha and contained incurred residues at 57 mg/kg.

No decrease in the levels of residues of paraquat in animal commodity matrices over time was observed under storage for up to 28 months. The test matrices represented a diverse selection of animal tissues, and the studies demonstrate the stability of paraquat under various storage conditions.

Definition of the residue

Paraquat is usually available as the dichloride salt or the bis(methylsulfate) salt but is determined as paraquat ion in analysis. Paraquat is known to adsorb strongly to soil, and most of the small amount incorporated into plant remains as paraquat (90%). Its metabolites were not found when paraquat was applied at normal rates. When it was applied post-emergence, most of the applied compound remained, with minimal amounts of photodegradation products, indicating the involvement of photolysis in the transformation of paraquat. The residue of concern in plants is paraquat ion.

In studies of metabolism in rats, cattle, goats, pigs and hens, the metabolic pathway was similar, producing minor levels of oxidized metabolites. The metabolic pathways in animals and plants are similar. In animals, the residue of concern is also paraquat ion.

The definition of the residue in all countries that provided national MRLs to the Meeting was paraquat ion.

All the identified metabolites have been covered by toxicological evaluations, owing either to their occurrence in rats or in independent studies. The ADI recommended by the JMPR is for paraquat cation.

The Meeting therefore agreed that the definition of residues for plant and animal commodities should be: Paraquat cation (for both compliance with MRLs and estimation of dietary intake).

Results of supervised trials on crops

When used for weed control, paraquat is not sprayed directly onto crops and is strongly adsorbed to soil. Therefore, little paraquat is expected to be found in harvested crops. After pre-emergence application, no residues were expected to be detected in the harvested crops, although some samples contained residues. After use as a harvest aid desiccant, however, paraquat is in direct contact with crops, and the residue levels tend to be much higher than when it is used for weed control.

The Meeting agreed that data from trials of pre-plant and pre-emergence application should be evaluated against any GAP available to the Meeting, regardless of the country or region; while data on

trials of post-emergence application and harvest aid desiccation should be evaluated against GAP of the country in which the trials were conducted or of a neighbouring country.

As degradation of paraquat on the surface of crops appears to involve photolysis, residue levels are expected to be similar in all crops, justifying estimation of group MRLs for paraquat.

For estimating STMR from the results of two or more sets of trials with different LOQs in which no residues exceeding the LOQs are reported, the lowest LOQ should be used, as stated in the 2002 *FAO Manual*, unless the residue level can be assumed to be essentially zero. The size of the trial database supporting the lowest LOQ was taken into account in making decisions in these cases.

Since maximum residue levels were estimated for a number of vegetable groups in which the levels were below the LOQ, the Meeting decided to withdraw the previous recommendation for vegetables (except as otherwise listed) of 0.05 * mg/kg.

In Germany, information is required on the possible contamination of fruits that have fallen onto ground treated with pesticides. Therefore, tests were carried out on apples, stone fruits, grapes and olives to simulate the residue situation in fruit used for juice and other processed products. Nevertheless, direct consumption of fruit picked up from the ground is regarded as inappropriate.

Citrus fruit

Numerous supervised residue trials have been carried out over several seasons and in several locations on orange in Italy and in California and Florida, USA, and on lime, lemon and grapefruit in Florida.

Paraquat is registered for the control of weeds around the base of citrus fruit trees at a maximum rate of 1 kg ai/ha as an inter-row spray, with no PHI, in Italy and at a maximum rate of 1.14 kg ai/ha as a directed spray, with no PHI, in the USA.

The residue levels of paraquat in whole mature *oranges* in trials in Italy and the USA were below the LOQs of 0.01, 0.02 or 0.05 mg/kg, even when paraquat was applied at twice or 30 times the maximum application rate, except in two trials. In one trial with an application rate of 2.44 kg ai/ha, mature fruit from one plot contained paraquat residues at a level of 0.01 mg/kg. In a trial with an application rate of 1.12 kg ai/ha, residue levels of 0.06 and 0.08 mg/kg were found in whole fruit. In this trial, however, the lower fruit-bearing branches were deliberately sprayed, the fruit fell onto sprayed weeds, and they were picked up from the ground within 3 days of spraying for analysis. Even though this represents the worst-case scenario, it does not reflect GAP in any country and is therefore inappropriate for use in estimating a maximum residue level. The residue levels in whole mature oranges in valid trials were, in ranked order: < 0.01 (15), 0.01, < 0.02 (two) and < 0.05 mg/kg (one).

In one trial in the USA, both juice and pulp were analysed for paraquat residues. Although the levels were below the LOQ of 0.01 mg/kg, the procedural recovery was too low for the results to be regarded as reliable.

In trials in the USA on *grapefruit*, *lemon* and *lime* in 1970 and 1972, with application rates reflecting GAP in the USA, the paraquat residue levels were < 0.01 (one) and < 0.05 mg/kg (three).

As the residue situation in oranges and other citrus fruits is similar and GAP is recommended for citrus fruits as a group in Italy and the USA, the Meeting considered it appropriate to establish a group maximum residue level for citrus fruits. The combined residue levels, in ranked order, were: < <u>0.01</u> (16), 0.01, < 0.02 (two) and < 0.05 (four) mg/kg. The Meeting estimated a maximum residue level of 0.02 mg/kg, an STMR of 0.01 mg/kg and a highest residue level of 0.02 mg/kg for paraquat in citrus fruits. The value of 0.02 mg/kg covers only the finite residue level found at 0.01 mg/kg.

Pome fruit

Trials were carried out on apples in Canada, Germany and the United Kingdom and on pears in Canada and Germany.

Paraquat is registered for use to control weeds around the base of pome fruit trees at a maximum rate of 0.66 kg ai/ha with one application and no PHI in the United Kingdom and at a maximum rate of 1.14 kg ai/ha with no PHI in the USA. No information on GAP was available for Canada or Germany, but the results of trials conducted in those countries were reviewed against the GAP of the USA and United Kingdom, respectively.

Trials on *apple* were conducted at rates of 1.12–4.48 kg ai/ha, and in one trial in the United Kingdom at a highly exaggerated rate of 12.3 kg ai/ha, about 20 times the maximum rate permitted in that country. In the latter trial, paraquat was applied directly to the bark of the trees to simulate worst-case conditions. In some cases, two applications were made, in the same or subsequent years. Apples were harvested 0–780 days after the last application. In trials on *pear*, paraquat was applied at rates of 1.0–4.48 kg ai/ha once or twice, and pears were harvested 0–77 days after the last application. Paraquat residue levels were below the LOQ of 0.01 mg/kg in all apples and pears taken from trees, even after treatment at rates as high as 20 times the maximum GAP rate.

In the trials in Germany, apples and pears taken from the trees were placed on the ground 6–7 days after application and collected about 7 days later for analysis. Residue levels of paraquat of 0.02–0.19 mg/kg were found in the apples, which could be attributed to the transfer of paraquat from the sprayed weed. The Meeting concluded that these data are not appropriate for use in estimating a maximum residue level.

As the residue situations in apples and pears are similar, and GAP is recommended for pome fruits or orchard fruits as a whole in all the countries that provided information on GAP, the Meeting considered it appropriate to establish a group maximum residue level for pome fruits. As the paraquat residue levels in all the valid trials were below the LOQ, even after application at exaggerated rates, the Meeting estimated a maximum residue level for pome fruits of 0.01* mg/kg, an STMR of 0 mg/kg and a highest residue level of 0 mg/kg.

Stone fruit

Trials were carried out on peaches, plums, apricots and cherries in Canada, Germany, the United Kingdom and the USA.

Paraquat is registered for use to control weeds around the base of stone fruit trees at a maximum rate of 0.66 kg ai/ha, with one application and no PHI for stone fruits in the United Kingdom and at a maximum rate of 1.14 kg ai/ha, with three applications and a 28-day PHI for stone fruits other than peaches in the USA; the PHI for use on peach trees in the USA is 14 days. No information on GAP was available from Canada or Germany, and the results of trials conducted in those countries were reviewed against the GAP of the USA and the United Kingdom, respectively.

The application rates in the supervised trials ranged from 0.22 to 4.48 kg ai/ha, applied to the base of the fruit trees up to three times in a season; the fruit was harvested from the trees 0–103 days after the last application. No residues of paraquat above the LOQ of 0.01 or 0.05 mg/kg were found in fruit harvested directly from the trees in any trial, even after spraying three times at a rate four times the maximum permitted rate. In most of the US trials, paraquat was applied one or two times instead of the maximum of three, but because of the higher application rates, the total amount applied was higher than the maximum allowed by GAP.

In trials on plums in the United Kingdom, paraquat was applied directly to suckers at rates of 0.22–1.34 kg ai/ha. No residues were found above the LOQ of 0.01 mg/kg in fruit harvested 21 or 55 days later.

In the trials in Germany, fruit were placed on sprayed weeds and collected for analysis about 1 week later. Small amounts of paraquat residues were found (0.02 and 0.04 mg/kg on peach, < 0.01 mg/kg on plum and 0.07 mg/kg on cherry) in the fruit samples, due to transfer from the sprayed weeds. As stone fruit intended for juice production is usually grown in orchards in which herbicides are rarely used, these data were not used for estimating a maximum residue level.

As the residue situations in stone fruits are similar and GAP is recommended for stone fruits or similar GAPs are established for peach and stone fruits excluding peach, the Meeting considered it appropriate to establish a group maximum residue level for stone fruits. As the paraquat residue levels were below the LOQ, even when applied at exaggerated rates and the methods of analysis in most of the trials had a LOQ of 0.01 mg/kg, the Meeting estimated a maximum residue level for stone fruits of 0.01* mg/kg and STMR and highest residue values of 0 mg/kg.

Berries and small fruit

Grape

Trials on residues in grapes have been conducted in Canada, Japan, Switzerland and the USA at rates of 0.3–4.4 kg ai/ha applied one to five times. Grapes were harvested from the vines at maturity 0–196 days after the last application. Four trials were conducted in Germany in which paraquat was applied between the rows of established vines at a rate of 1.0 kg ai/ha and grapes were sampled from the vines 0–14 days after application.

Paraquat is registered for weed control around grape vines at a maximum rate of 0.72 kg ai/ha, with five applications and a 30-day PHI in Japan and a maximum rate of 1.14 kg ai/ha, with the number of applications and the PHI unspecified in the USA. No information on GAP was available from Canada, Germany or Switzerland, but the results of trials in Canada were reviewed against US GAP.

In all trials in Canada, Japan and the USA reviewed against respective GAP, grapes obtained directly from the vine did not contain paraquat residues at levels above the LOQ of 0.01 or 0.02 mg/kg, even when applied at five times the recommended rate or with a shorter PHI.

In the German trials, bunches of grapes were also placed on the sprayed weed a few days after application and collected 7 days later for analysis. Small amounts of paraquat residues (0.04, 0.07, 0.09, 0.10, 0.13 and 0.17 mg/kg) were found in the grapes due to transfer from the sprayed weeds. When the fruits were sampled directly from the vine, the levels of residues were always below the LOQ of 0.01 mg/kg (six trials), which supports the results of the trials conducted in Canada, Japan and the USA.

The residue levels of paraquat in grapes in the trials that met the respective GAP or were conducted at higher rates were: < 0.01 (16), < 0.02 (three) and < 0.05 (two) mg/kg.

Cane fruit

Trials on residues were conducted in Canada on red and blackcurrants, blueberries, loganberries, gooseberries and raspberries at rates of application of paraquat of 0.56–2.24 kg ai/ha. Paraquat was applied once and the fruit was harvested 20–111 days after application.

GAP for cane fruit in the USA is a maximum rate of 1.14 kg ai/ha, with the number of applications and PHI unspecified.

Even at double the application rate, cane fruit did not contain paraquat residues at levels above the LOQ of 0.01 mg/kg. The residue levels in 25 trials following GAP or conducted at higher rates were < 0.01 mg/kg.

Strawberry

Supervised trials were conducted in France, Germany and the United Kingdom in which paraquat was used to control runners of strawberry plants at rates of 0.42–1.32 kg ai/ha once or twice. Berries were harvested 47–226 days after the last application. Three trials in Germany were conducted in plastic greenhouses.

GAP in the United Kingdom for strawberries is a maximum rate of 0.66 kg ai/ha, with one application and PHI unspecified.

The residue levels of paraquat in strawberries in trials following GAP or conducted at higher application rates were < 0.01 (six) and < 0.05 mg/kg.

As the samples analysed in all the trials except that in which grapes were kept and taken from the ground did not contain paraquat residues at levels above the LOQs and the application rate in the respective GAP is similar, the Meeting decided to propose a group maximum residue level for small fruits and berries. The residue levels in these fruits, in ranked order, were: < 0.01 (47), < 0.02 (three) and < 0.05 mg/kg (three). The Meeting, considering that use of modern analytical methods would enable lower LOQs, agreed to disregard residue levels of < 0.05 mg/kg and < 0.02 mg/kg and estimated a maximum residue level of 0.01* mg/kg and STMR and highest residue values of 0 mg/kg.

Olive

Trials on residues in olives have been carried out in Greece, Italy, Spain and the USA (California).

Paraquat is registered for controlling weeds around the base of olive trees at a maximum rate of 1 kg ai/ha, with the number of applications unspecified and a 40-day PHI in Italy and at a maximum rate of 1.14 kg ai/ha, with four applications and a 13-day PHI in the USA. The results of trials conducted in Greece and Spain were reviewed against GAP in Italy.

In trials in Italy, paraquat was applied at rates of 0.54–1.8 kg ai/ha to the base of trees, and olives were harvested from the ground or trees 7–21 days after application. Although the delay was shorter than the recommended PHI of 40 days, the residue levels in the olives were < 0.05 and < 0.1 (two) mg/kg, indicating that at a PHI of 40 days the levels are likely to be < 0.1 mg/kg. No residues (< 0.05 mg/kg) of paraquat were detected in the oil from these fruits.

In one trial in the USA, paraquat was applied four times at an exaggerated rate (5.6 kg ai/ha; 22.4 kg/ha total) and the fruit was harvested from the trees 13 days later for analysis. The residue levels of paraquat were below the LOQ of 0.05 mg/kg, as were the levels in oil and cake prepared from the olives.

In six trials in Spain, olives were harvested from the ground 0, 1 and 7 days after application of paraquat at 0.60 kg ai/ha, simulating the worse-case scenario of collecting olives intended for oil production. In these trials, the application rate was 60% of the maximum allowed in Italy, but the olive fruit were harvested much earlier than the PHI of 40 days. The residue levels in whole fruit were 0.64–10 mg/kg, indicating that there had been transfer of paraquat from the sprayed weeds to the olives. In all the oil produced from these samples, however, the maximum residue levels of paraquat were 0.06 mg/kg, indicating that paraquat is not extracted into oil, as might be expected from its chemical nature.

In other trials in Spain, mature olives were sprayed directly on the ground with paraquat at rates of 0.36–1.3 kg/ha, and the fruit was analysed 3–17 days after application. The residue levels of paraquat in the olives were 0.08–4.4 mg/kg. Residues of paraquat did not transfer to extracted oil, and washing appeared to reduce the levels on the fruit.

In one trial in Greece, mature olives were sprayed directly with paraquat at a rate of 1.0 kg ai/ha to simulate direct spraying on fallen fruit in collection nets during weed control. No residues were

found at levels above the LOQ (0.05 mg/kg) in oil extracted from treated fruit harvested 5 days after application.

Olives for oil production are often harvested from the ground and paraquat used for weed control may occasionally be applied directly to the fallen fruit on the ground. The whole fruit will contain some paraquat residue, either through transfer from treated vegetation or through direct spraying. Although the olives may contain relatively high levels of paraquat, no transfer of paraquat to oil occurs. This practice is not in compliance with GAP for olives.

The residue levels in olives taken directly from trees were: < 0.05 and < 0.10 mg/kg (two). In another trial, the level was < 0.05 mg/kg in olives taken from ground that had not been directly sprayed. The residue levels in one US trial conducted at five times the usual rate were below the LOQ of 0.05 mg/kg, indicating that when paraquat is applied in accordance with GAP no residues are expected to occur in olive fruit. The Meeting estimated a maximum residue level of 0.1 mg/kg to replace the previous recommendation for olive at 1 mg/kg. The Meeting also estimated an STMR of 0.05 mg/kg and a highest residue level of 0.1 mg/kg.

Assorted tropical fruits minus inedible peel

Trials on residues were carried out on *passion fruit* in Hawaii, USA, at an application rate of 1.12–4.48 kg ai/ha, to control weeds. Fruit was harvested 1–28 days after application. GAP in the USA for use on passion fruit is a maximum rate of 1.05 kg ai/ha, with an unspecified number of applications and PHI. The residue level in whole fruit in a trial complying with the maximum GAP was 0.13 mg/kg. After application at a rate higher than the maximum GAP, residue levels of up to 0.19 mg/kg were found in whole fruit. The levels in the edible pulp of all passion fruits analysed in the trials, regardless of PHI, ranged from < 0.01 to 0.02 mg/kg at 1.12 kg ai/ha and from < 0.01 to 0.06 mg/kg at higher rates. Higher levels were found in peel than in the edible portion.

Trials on residues were carried out on *kiwifruit* in California, USA, at an application rate of 0.56–2.24 kg ai/ha, three times, to control weeds. Fruit was harvested 7–14 days after the last application. The US GAP for kiwifruit is a maximum rate of 1.14 kg ai/ha, with the number of applications unspecified and a 14-day PHI. The residue level in kiwifruit in one trial conducted in accordance with the maximum US GAP was < 0.01 mg/kg. Even at a higher application rate or a shorter PHI, the levels were below the LOQ of 0.01 mg/kg.

Trials on *guava* were carried out in two locations in Hawaii, USA, with three different application rates of 1.12–4.48 kg ai/ha at each location. Fruit was harvested 1–28 days after application. The US GAP for guava is identical to that for passion fruit. The residue levels of paraquat in all edible pulp and peel analysed were below the LOQ of 0.01 mg/kg at the maximum GAP rate and at rates up to four times the maximum GAP. No residue was found at levels above the LOQ of 0.01 or 0.02 mg/kg in juice, discarded skin or seed obtained from guava treated at 1.12 or 4.48 kg/ha with a 6-day PHI. Although no information was available on residues in whole fruit, levels above the LOQ were not expected in whole fruit in view of the residue situation in pulp, peel and other fractions.

Trials were carried out on *banana* in Honduras, with three applications of paraquat at 1.4 kg ai/ha or a single application at double this rate, to control weeds in established plantations. Fruit was harvested 0–90 days after the last application. As no information was available on GAP in Honduras, the data were reviewed against GAP of the USA (maximum rate of 1.14 kg ai/ha). The residue levels of paraquat in flesh (0- and 3-day PHI) and whole fruit (≥ 7-day PHI) were below the LOQ (0.01 mg/kg) in three trials, except in skin from fruit harvested immediately after application.

Except in the trials on passion fruit, the residue levels in tropical fruits in 10 trials conducted according to the respective GAP were all below the LOQ (< 0.01 mg/kg). The Meeting estimated a maximum residue level for paraquat in assorted tropical fruits with inedible peel, excluding passion fruit, of 0.01* mg/kg. The Meeting decided to withdraw the previous recommendation for passion fruit.

The residue levels in edible portions of these fruit were below the LOQ: < 0.01 (11) mg/kg. The Meeting estimated STMR and highest residue values for paraquat in assorted tropical fruits minus inedible peel, excluding passion fruit, of 0.01mg/kg.

Bulb vegetables

Trials on residues were conducted on *onion* in Canada, Germany and the United Kingdom in the 1960s. Paraquat is registered in the USA for pre-plant or pre-emergence application to onion in a limited number of states at a maximum rate of 1.14 kg ai/ha, with one application and a 60-day PHI (200 days in California). Uses on bulb vegetables are not included in the label in the United Kingdom.

In one Canadian trial at twice the GAP rate and with a shorter PHI (36 days), the residue levels were below the LOQ of 0.01 mg/kg. In another Canadian trial at an application rate of 1.12 mg/kg, the levels were also < 0.01 mg/kg, but the PHI was 143 days.

Trials were conducted in Germany for post-emergence directed application and for harvest aid uses, but there was no related GAP.

In one trial conducted in the United Kingdom of pre-emergence application on spring onion, the residue level was 0.02 mg/kg, but the application rate was > 30% higher than the maximum rate allowed in the USA. A further trial on spring onion involved directed post-emergence application, for which no information on GAP was available.

The Meeting concluded that there were insufficient data to recommend a maximum residue level for paraquat in onion bulb or bulb vegetables.

Brassica vegetables

Residue trials were carried out on *broccoli* in Canada; *Brussels sprouts* in The Netherlands (harvest aid); *cabbage* in Canada, Japan, Spain and the USA; and *cauliflower* in Canada. Paraquat was applied once or twice at 0.67–2.2 kg ai/ha for inter-row weed control, and the crop was harvested 5–52 days after the last application.

Paraquat is registered for use in the cultivation of *Brassica* vegetables during seed-bed preparation as a pre-plant or pre-emergence treatment, or applied as a post-emergence directed or guarded spray for inter-row weed control. GAP in Japan is a maximum rate of 0.36 kg ai/ha, with three applications and a 30-day PHI, for broccoli, cabbage, cauliflower and Chinese cabbage as pre-plant inter-row applications. GAP in the USA is a maximum rate of 1.14 kg ai/ha, with the number of applications and PHI unspecified, for *Brassica* vegetables as pre-plant, pre-emergence treatment.

In trials conducted on broccoli, cabbage and cauliflower in Canada, the residue levels were below the LOQ of 0.01 mg/kg, even when applied at double the rate. The exception was one trial in Canada in which cabbage harvested 51 days after treatment at twice the rate contained a residue level of 0.06 mg/kg. The residue levels were < 0.01 (two) and 0.06 mg/kg.

In two trials conducted on cabbage in Japan, the residue levels were below the LOQ of 0.03 mg/kg even after application at a higher rate of 0.96 kg ai/ha and a shorter PHI of 5 days. At a highly exaggerated rate of 19.2 kg ai/ha but with only one application and a longer PHI of 52 days, the residue levels were also < 0.03 mg/kg.

No information was available on GAP that would allow evaluation of trials conducted in Spain.

Trials on Chinese cabbage were conducted in the USA in which paraquat was applied once as pre-emergence treatment at 1.05 kg ai/ha, followed by three post-emergence directed applications at 0.56 kg ai/ha. The residue levels were < 0.05 and 0.07 mg/kg. The US label allows only pre-plant and pre-emergence applications.

Trials on Brussels sprouts in The Netherlands involved a direct harvest aid application to the vegetable. In these trials, the unwashed vegetable contained a residue level of 7.3 mg/kg after 31 days, while washed vegetable had a reduced level of 1.6 after 31 days. Harvest aid desiccation was not, however, included in the labels provided to the Meeting.

The residue levels in these crops in trials that followed GAP and in trials that showed residue levels below the LOQ were, in ranked order: < 0.01 (two), ≤ 0.03 (two) and 0.06 mg/kg. The Meeting concluded that there were insufficient data for estimating a maximum residue level for *Brassica* vegetables.

Fruiting vegetables

Numerous residue trials were carried out on tomatoes in Canada and the USA, on cucumbers, melons and summer squash in the USA and on peppers in Canada and the USA.

Paraquat is registered in the USA for use on tomatoes for pre-plant or pre-emergence application at a maximum rate of 1.14 kg ai/ha, with an unspecified number of applications and a 30-day PHI; on tomatoes for post-emergence directed spray at a maximum rate of 0.55 kg ai/ha, with an unspecified number of applications and a 30-day PHI; on peppers by directed spray application at a maximum rate of 0.55 kg ai/ha, with three applications and no PHI; and on other fruiting vegetables for pre-plant or pre-emergence application at a maximum rate of 1.14 kg ai/ha, with unspecified number of applications and PHI.

The trials in Canada on *tomatoes* were for pre-emergence or pre-planting weed control, in which paraquat was used at a low rate of 0.11 kg ai/ha. Trials on tomatoes in the USA involved post-emergence directed application at 0.56–2.24 kg/ha and an exaggerated single high pre-emergence application at a rate of 11.2 kg ai/ha or pre-emergence application of 1.12 kg ai/ha followed by three inter-row directed applications at 2.8 kg ai/ha. Although samples were harvested 21 days after treatment, 30% shorter than the PHI in US GAP of 30 days, the residue levels in tomatoes were below the LOQ of 0.01 mg/kg after application at 0.56 kg ai/ha for post-emergence directed application, except in one trial in which levels up to 0.04 mg/kg were found. After application at exaggerated rates, the residue levels were still below the LOQ of 0.005 or 0.01 mg/kg or at a maximum of 0.02 mg/kg.

The residue levels in trials following GAP or conducted at higher application rates were, in ranked order: < 0.005 (two), ≤ 0.01 (seven) and 0.04 mg/kg.

The trials on *sweet peppers* were for use of paraquat in inter-row weed control at 0.56–2.2 kg ai/ha. The residue levels in trials at maximum GAP were < 0.01 and 0.01 mg/kg. The levels after exaggerated application rates were either below the LOQ of 0.01 mg/kg, 0.03 mg/kg (once at 1.12 kg ai/ha pre- emergence and four times at 1.12 or 2.24 kg ai/ha post-emergence applications) or 0.02 mg/kg (one trial).

The Meeting considered it appropriate to evaluate residues in tomato and peppers together for estimating the maximum residue level for fruiting vegetables, other than cucurbits. The combined levels were: < 0.005 (two), ≤ 0.01 (eight), 0.01 and 0.04 mg/kg. The Meeting estimated a maximum residue level for fruiting vegetables, other than cucurbits, of 0.05 mg/kg, an STMR of 0.01 mg/kg and a highest residue level of 0.04 mg/kg.

In trials on *cucumbers*, *melons* and *summer squash* in California (USA), paraquat was applied at 1.12 kg ai/ha pre-emergence, followed by three inter-row applications at 0.56 kg ai/ha. While US GAP allows pre-emergence application at a maximum of 1.12 kg ai/ha, the residue levels of paraquat in all 12 trials were below the LOQ of 0.025 mg/kg. The Meeting estimated a maximum residue level for cucurbits of 0.02 mg/kg and STMR and highest residue values of 0 mg/kg.

Leafy vegetables

Trials for residues were conducted on lettuce in Canada, Germany, Spain, the United Kingdom and the USA, on kale in France, Italy and the United Kingdom and on turnip greens in the USA.

Paraquat is registered for pre-emergence application on collard and lettuce in the USA at a maximum rate of 1.14 kg ai/ha, with the number of applications and PHI unspecified. Uses on leafy vegetables are not included on labels in Italy or the United Kingdom.

Trials on residues on *lettuce* were conducted in Canada, Germany, Spain, the United Kingdom and the USA at application rates of 0.42–2.24 kg/ha; lettuce was sampled 0–147 days after application. In trials conducted in Canada and the USA following US GAP, the residue levels in untrimmed head or bunch were 0.01, 0.04 and 0.05 mg/kg.

The results of trials in the United Kingdom were evaluated against US GAP, as the uses were similar in trials in the two countries. The residue levels in unwashed lettuce head in trials following US GAP were < 0.01, 0.01 and 0.02 mg/kg.

Residue levels up to 1.4 mg/kg were found in German trials on lettuce harvested immediately after one or two applications of paraquat for post-emergence inter-row weed control. The residues were believed to have derived from spray drift onto the outer leaves. In most of these trials, the whole lettuce head was analysed without removal of outer wrapper leaves that were yellow and withered. The residue levels had declined to close to the LOQ (< 0.01 mg/kg) by 21 days after harvest. The results of trials in Germany and Spain could not be evaluated as no information on GAP in Europe was available.

Residue trials on *kale* were carried out in France, Italy and the United Kingdom at rates of 1.0–2.24 kg/ha, and kale was sampled 0–147 days after application. As no information was available on GAP in Europe, these data were not evaluated.

Six trials on *turnip greens* were carried out in the USA at a rate of 1.12 kg/ha, with sampling 55–128 days after application. The levels of paraquat residue were < 0.025 (three), 0.03, 0.04 and 0.05 mg/kg.

As the US GAPs for collard and lettuce are identical and the residue situations for these crops were similar, the Meeting considered it appropriate to combine the results for estimating a maximum residue level for leafy vegetables. The combined residue results, in ranked order were: < 0.01, 0.01 (two), 0.02, < 0.025 (three), 0.03, 0.04 (two) and 0.05 (two) mg/kg. The Meeting estimated a maximum residue level for paraquat in leafy vegetables of 0.07 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 0.05 mg/kg.

Legume vegetables and pulses

Residue trials were conducted on beans (with pod and dry) in Canada, Germany, Italy, The Netherlands and Spain, on broad beans in Spain, on peas in Australia, Canada and the USA, and on soya beans in Brazil and the USA.

Paraquat is registered for weed control and harvest aid on legume vegetables and pulses in Australia, Brazil and the USA as follows:

Country	Maximum rate (kg ai/ha)	No. of applications	PHI (days)	Crop	Type of application
Australia	0.2		14	Chickpea	Over-the-top spray
	0.2		14	Field pea	Over-the-top spray
	0.43			Soya bean	Pre-plant
Brazil	0.6	1	7	Soya bean	Pre-plant
	0.5	1	7	Soya bean	Desiccation

Country	Maximum rate (kg ai/ha)	No. of applications	PHI (days)	Crop	Type of application
USA	1.14		–	Beans (lima, snap)	Pre-plant, pre-emergence
	1.14		–	Pea	Pre-plant, pre-emergence
	0.55	2	7	Pulses	Harvest aid
	1.14		–	Soya bean	Pre-plant or pre-emergence
					Should not exceed 1.9 l per season
	0.14	2	–	Soya bean	Post-emgence directed spray
					Second and final application 7–14 days later if needed
	0.28		15	Soya bean	Harvest aid

Uses on legumes and pulses were not included in the European labels provided to the current Meeting.

Residue trials were carried out on *dry beans* (genus *Phaseolus*) in Germany, Italy, The Netherlands and Spain, in which paraquat was used for pre-emergence weed control at single application of 0.56 or 2.24 kg ai/ha or post-emergence directed inter-row weeding at rates of 0.28–1.12 kg ai/ha. In trials in Europe, young pods were harvested 0–7 days after treatment and analysed. The residue levels in beans in pods were < 0.05–0.10 mg/kg (five trials). As no related GAP was available, these results were not used in estimating a maximum residue level. The Meeting concluded that there were insufficient data to estimate a maximum residue level for legume vegetables.

The residue levels of paraquat in dry beans in Canadian trials after pre-emergence application following GAP were < 0.01 (two), < 0.05 and 0.07 mg/kg.

Residue trials were conducted on *broad beans* in Spain after post-emergence directed spray. The residue levels in seeds harvested on the day of application were < 0.05 mg/kg (two); however, no information was available on related GAP.

Residue trials were carried out on *peas* in Canada and the United Kingdom with paraquat used for pre-emergence weed control at single applications or post-emergence directed inter-row weeding at rates of 0.14–1.68 kg ai/ha and harvesting 55–152 days after application. The residue levels of paraquat in seeds were below the LOQ of 0.01 or 0.05 mg/kg in trials with post-emergence application; however, no GAP was available for post-emergence application on peas.

Paraquat was applied at 0.20 or 1.12 kg ai/ha to field peas and chick peas as a harvest aid desiccant in Australia and the USA, with samples taken 1–38 days after application. The resulting residues of paraquat in seed in trials following GAP were found at levels of: 0.05, 0.15, 0.23, 0.25, 0.31 and 0.41 mg/kg.

A number of trials were conducted on *soya beans* in Brazil between 1981 and 1983 with a harvest aid desiccation application of paraquat at 0.25–0.80 kg/ha and sampling 2–21 days after application. The residue levels of paraquat in seed in trials following GAP in Brazil were: < 0.02, 0.03 (two), < 0.05 (two), 0.07, 0.08, 0.09, 0.10, 0.11 (two), 0.13, 0.16 (two) and 0.28 (three) mg/kg.

In trials conducted in the USA with pre-emergence application with or without a post-emergence directed application at 0.14–1.4 kg/ha, the residue levels of paraquat in soya beans harvested 3–147 days after the last application in trials following GAP were < 0.025 (nine) and 0.03 mg/kg.

Other trials were conduced in the USA on harvest aid desiccation application at 0.28 or 0.56 kg/ha and sampling 6–36 days after application. The residue levels of paraquat in seeds in trials following GAP were: < 0.01, 0.02 (four), 0.03 (two), 0.04 (two), 0.05, 0.06, 0.07, 0.08 (two), 0.09, 0.12 and 0.13 mg/kg. The hulls of treated soya beans contained higher residues than seeds.

The results of these trials clearly indicate that the levels of residues arising from harvest desiccant uses are higher than those from pre-emergence or post-emergence application.

The Meeting considered it appropriate to combine the results of trials on field peas and chick peas in Australia and on soya beans in Brazil and the USA in which paraquat was used as a harvest aid desiccant to estimate a group maximum residue level for pulses. The combined residue levels in seeds were, in ranked order: < 0.01 (two), < 0.02, 0.02 (four), 0.03 (four), 0.04 (two), < 0.05 (two), 0.05 (two), 0.06, 0.07 (two), 0.08 (three), 0.09 (two), 0.10, 0.11 (two), 0.12, 0.13 (two), 0.15, 0.16 (two), 0.23, 0.25, 0.28 (three), 0.31 and 0.41 mg/kg. The Meeting estimated a maximum residue level of 0.5 mg/kg to replace the previous recommendation for soya bean and an STMR of 0.08 mg/kg and a highest residue level for pulses of 0.41 mg/kg.

Root and tuber vegetables

Paraquat is registered for use at a maximum rate of 0.36 kg ai/ha with three applications and a 30-day PHI in Japan for pre-plant, inter-row application on carrot and in the USA at a maximum rate of 1.14 kg ai/ha for pre-emergence treatment of root and tuber vegetables excluding potatoes.

Two residue trials carried out on *beetroot* in Canada and the United Kingdom for pre-emergence application in compliance with US GAP resulted in residue levels of < 0.01 and 0.03 mg/kg.

Residue trials were conducted in the United Kingdom on beetroot and *sugar-beet* in which paraquat was used pre-sowing or pre-emergence at 1.68 kg ai/ha, followed by two directed inter-row applications at 2.24 kg ai/ha after crop emergence. No information was available, however, on GAP for post-emergence application from Europe.

In trials conducted in four states of the USA with pre-emergence application at 1.12 kg ai/ha, the residue levels in sugar-beet roots harvested 136–178 days after application were < 0.05 mg/kg (six) after a single pre-emergence application at 1.12 kg ai/ha. After application at an exaggerated rate of 5.6 kg ai/ha, the residue levels in unwashed root were < 0.05 mg/kg.

Residue trials on *carrots* with use of paraquat for pre-emergence or inter-row weed control have been carried out in Canada, Japan, Germany and the United Kingdom. The residue levels of paraquat in carrot in the Japanese trials after both pre-emergence and inter-row applications were all below the LOQ of 0.03 mg/kg, despite a shorter PHI or use of a highly exaggerated rate of 19.2 kg ai/ha. The residue levels in carrot in four trials following GAP or conducted at higher rates or shorter PHI were < 0.03 mg/kg. In Canadian trials, the residue levels were below the LOQ of 0.01 mg/kg, even in one trial in which the rate was doubled and the PHI shorter.

As no information was available on GAP in Europe, the data from German trials with post-emergence application were not considered in estimating the maximum residue level.

Residue trials were carried out on *parsnips* and *swedes* in the United Kingdom and on *turnips* in Canada and United Kingdom with use of paraquat for pre-emergence weed control (Canada) or pre-emergence followed by inter-row weed control (United Kingdom). The rates of application were 0.56–2.24 kg ai/ha. Turnip, swede and parsnip roots were harvested 49–122 days after application. The residue levels of paraquat in turnips in two Canadian trials that followed US GAP were < 0.01 mg/kg. No information on GAP was available for post-emergence application in Europe.

One trial was conducted in France on *black salsify*, in which paraquat was applied as an inter-row treatment at 0.5 and 0.8 kg ai/ha. There were no residues (< 0.02 mg/kg) in salsify roots harvested 8 and 80 days after treatment; however, no information on GAP was available.

The combined residue levels in beetroot, sugar-beet, carrots and turnips were, in ranked order: < 0.01 (four), < 0.03 (four), 0.03 (two) and < 0.05 (six) mg/kg.

Potato

Trials were carried out on potatoes in Canada, Germany, the United Kingdom and the USA for pre-emergence, post-emergence and harvest aid applications of paraquat.

Paraquat is registered in the United Kingdom for pre-emergence use at a maximum rate of 0.66 kg ai/ha with one application. It is registered in the USA for pre-plant and pre-emergence broadcast application at a maximum rate of 0.55 kg ai/ha and for broadcast application for pre-harvest vine killing and weed dessication at a maximum rate of 0.42 kg ai/ha with a 3-day PHI. The latter application is restricted to fresh market produce, with a restriction of 2.3 l/ha per season; split applications must be applied a minimum of 5 days apart.

Trials were carried out in Germany with post-emergence directed application. The residue levels were below the LOQ of 0.01 mg/kg.

Several residue trials were carried out in Canada and the USA in which paraquat was applied for weed control by pre-emergence or post-crop emergence application at a rate of 0.20–1.12 kg ai/ha. The residue levels in the tubers in trials following US GAP were < 0.01 (eight) and 0.02 mg/kg. At double the application rate, the residue levels were below the LOQ of 0.01 mg/kg.

Trials were also carried out on harvest aid desiccant use in Canada, the United Kingdom and the USA. The US label allows use of paraquat for vine killing and weed desiccation at a maximum of 0.42 kg ai/ha, with a PHI of 3 days, but in these trials rates equivalent to or higher than twice the maximum rate or a much longer PHI were used. Harvest aid use is not included in the United Kingdom label.

The residue levels in trials of pre- and post-emergence application were < 0.01 (eight) and 0.02 mg/kg. The levels in trials with double the application rate in the USA and in trials conducted in Germany were all below the LOQ.

The Meeting decided to combine the results from trials on beetroot, sugar-beet, carrot, turnip and potato. The combined residue levels, in ranked order, were: < 0.01 (12), <u>0.02</u>, < 0.03 (four), 0.03 (two) and < 0.05 (six) mg/kg. The Meeting estimated a maximum residue level of 0.05 mg/kg, an STMR of 0.02 mg/kg and a highest residue level of 0.05 mg/kg for root and tuber vegetables. The maximum residue level replaces the previous recommendation for potato.

Stem vegetables

Residue trials have been carried out on asparagus, celery and globe artichokes in Canada and the USA with use of paraquat for post-emergence directed inter-row weeding at rates of 1.12–3.25 kg ai/ha in a single application. Three applications of 1.12 or 1.35 kg/ha on artichokes were also tested.

Paraquat is registered in the USA for *asparagus* at a maximum rate of 1.14 kg ai/ha for pre-plant and pre-emergence broadcast or banded over-row application and at the same maximum rate with a 6-day PHI for asparagus more than 2 years old by broadcast or banded over-row application. The residue levels were < 0.02 (two) and < 0.05 mg/kg.

Although trials were conducted on *celery* in Canada and on *artichoke* in the USA, no information on GAP for these crops was available. The Meeting concluded that the data were insufficient for estimating a maximum residue level for asparagus.

Cereal grains

1.1 Maize

Residue trials were conducted on maize in Canada, Italy, the United Kingdom and the USA with pre- and post-emergence applications and harvest aid uses.

Paraquat is registered for use in the USA at a maximum rate of 1.14 kg ai/ha for pre-plant or pre-emergence broadcast of banded over-row applications and at a maximum rate of 0.55 kg ai/ha for post-emergence directed spray. Residue trials were conducted with use of paraquat for pre-emergence weed control or for post-emergence directed spray in Canada and the USA at rates of 0.28–1.12 kg ai/ha.

In a series of trials in the USA in 1987, one pre-emergence application at 1.12 kg ai/ha and two post-emergence applications at 0.31 kg ai/ha were made. Although the post-emergence application rate was not as high as the maximum rate, the pre-emergence application rate was the maximum allowed for pre-emergence application. The Meeting considered that these trials were conducted in accordance with US GAP. The residue levels in trials in Canada and the USA conducted in accordance with US GAP were: < 0.01 (eight) and < 0.025 mg/kg (16). In trials with higher application rates (up to four times), the residue levels were below the LOQ. The levels in maize cobs were also below the LOQ of 0.01 mg/kg (two trials).

In two residue trials in Italy, paraquat was applied pre-emergence at 0.92 kg ai/ha. The residue levels in cob were < 0.05 mg/kg; however, no analysis of kernels or grain was reported.

Trials were conducted in South Africa and the United Kingdom with post-emergence application; however, owing to the lack of relevant GAP for South Africa and the fact that post-emergence application is not included on the label in the United Kingdom, the results of these trials could not be evaluated by the Meeting.

Several trials were conducted in the USA on use of paraquat as a harvest aid desiccator at rates of 0.56–1.12 kg/ha. This use is not included in US GAP, although it is allowed in Argentina, Brazil and Uruguay.

On the basis of the residue levels in maize grain in trials with paraquat applied pre- or post-emergence in Canada and the USA, < 0.01 (eight) and < 0.025 mg/kg (16), the Meeting estimated a maximum residue level of 0.03 mg/kg to replace the previous recommendation for maize and STMR and highest residue values of 0.025 mg/kg.

Sorghum

A number of residue trials were conducted in the USA, where paraquat is registered for use on sorghum at a maximum rate of 1.14 kg ai/ha, with a PHI of 48 days for grain and 20 days for forage, for pre-plant or pre-emergence broadcast application, and at a maximum rate of 0.55 kg ai/ha in two applications with the same PHIs for post-emergence directed spray. In the latter application, the applications must not exceed 2.5 l per season.

Several residue trials were carried out in the USA in several years and locations, in which paraquat was applied for weed control, either pre-emergence, post-crop emergence directed or as a harvest aid, at rates of 0.21–7.8 kg ai/ha. Samples were taken 20–131 days after pre-emergence or post-emergence directed application. The residue levels in grain in 12 trials conducted in accordance with maximum GAP for pre-emergence or post-emergence applications were all < 0.025 mg/kg. When both pre- and post-emergence applications were made, if the post-application rate was in compliance with GAP, the residue results were taken into consideration in estimating the maximum residue level. In

one trial with one pre-emergence application at 0.56 kg ai/ha followed by a post-emergence application at 0.56 kg ai/ha, a residue level of 0.01 mg/kg was found.

In harvest aid desiccation applications, paraquat was applied at a rate of 0.21–2.8 kg/ha, and sorghum was sampled 7–49 days after application. Harvest aid desiccant use is not included on the US label.

The Meeting estimated a maximum residue level of 0.03 mg/kg to replace the previous recommendation and STMR and highest residue values of 0.025 mg/kg for sorghum.

Rice

Trials on residues of paraquat on rice were conducted in Guatemala, Italy and the USA. Paraquat is registered for use on rice in the USA by pre-plant or pre-emergence broadcast at a maximum rate of 1.14 kg ai/ha, with no PHI specified.

Two trials were conducted in Italy in 1993, in which paraquat was applied at a rate of 0.92 kg ai/ha to the seed bed 5 days before rice was sown. Rice grain and straw samples taken at harvest did not contain residues of paraquat at levels above the LOQ of 0.05 mg/kg.

Three residue trials were conducted in Guatemala in 1983 in which paraquat was applied as a pre-emergence treatment at rates of 0.30 and 1.0 kg ai/ha to rice. Rice grain and straw samples were taken at harvest. The residues in de-husked rice in one trial conducted in compliance with the maximum rate in US GAP were < 0.05 mg/kg, but residues in rice grain were not analysed.

Residue trials were conducted in the USA in 1978 and 1982 in which paraquat was applied as a pre-emergence treatment at rates of 0.56 and 1.12 kg ai/ha to rice. In trials conducted at the maximum GAP, the residue levels in rice grain were below the LOQ of 0.01 (two) or 0.02 mg/kg. No trials were conducted at rates higher than the maximum allowed in US GAP for rice.

The Meeting concluded that there were insufficient data to estimate a maximum residue level and withdrew the previous recommendation for rice and rice, polished.

Tree nuts

It is common practice to harvest nuts from the ground, and this may result in residues of paraquat in the nuts.

Supervised residue trials were carried out over a number of years in Italy on *hazelnuts* and in the USA on *almonds* (California), *macadamia nuts* (Hawaii), *pecans* (Alabama and Texas), *pistachio nuts* (California) and *walnuts* (California).

Paraquat is registered for use on hazelnuts in Italy at a maximum rate of 1 kg ai/ha with a 40-day PHI and on walnuts at the same maximum rate but with no PHI specified. In the USA, paraquat is registered for use on pistachio nuts at a maximum rate of 1.14 kg ai/ha with a 7-day PHI, with the proviso that no more than two applications should be made after the nuts have split. It is registered for use in the USA on other tree nuts at the same maximum rate with no specification of the number of applications or PHI.

Two trials were conducted in Italy in which hazelnuts were harvested from the ground 1–10 days after treatment around the base of the trees at rates of 0.54–1.8 kg ai/ha. Although the PHI was shorter than 40 days, the residue levels in shelled nuts were below the LOQ of 0.05 mg/kg in one trial. At almost twice the maximum application rate and with a shorter PHI of 10 days, the levels were still below the LOQ.

In a trial in the USA, paraquat was applied at rates of 0.56–4.5 kg ai/ha one to eight times, to control weeds under mature nut trees. In some cases, applications were made over 2 years. Nuts were harvested, in some cases immature, 1–171 days after the last application. The residue levels in shelled nuts in trials following GAP were: < 0.01 (seven), 0.01, 0.02 and < 0.05 (three) mg/kg.

The combined results of all the trials, in ranked order, were: ≤ 0.01 (seven), 0.01, 0.02 and < 0.05 (four) mg/kg. The Meeting estimated a maximum residue level for paraquat in tree nuts of 0.05 mg/kg, an STMR of 0.01 mg/kg and a highest residue level of 0.05 mg/kg.

Oil seeds

Cotton-seed

Paraquat is registered for use on cotton in the USA at a maximum rate of 1.14 kg ai/ha, with no specification of the number of applications of PHI, for pre-plant or pre-emergence treatment, and at a maximum rate of 0.55 kg ai/ha, with repeated application if necessary and a 3-day PHI as a harvest aid, with the proviso that a total of 1.5 l should not be exceeded in this use.

Residue trials were conducted in the USA over several years and locations, involving pre-emergence applications at 1.12 kg/ha and harvesting 4–176 days after application. The residue levels in fuzzy seed in trials at the maximum GAP were < 0.01 (four) and 0.04 mg/kg.

In numerous trials with pre-emergence application followed by harvest aid desiccation application or a single application as harvest aid desiccant, the residue levels of paraquat in fuzzy seed in trials following maximum GAP were: 0.07, 0.09, 0.15, 0.16 (two), 0.18, 0.21, 0.23, 0.30, 0.34, 0.35, 0.38, 0.44, 0.46, 0.49, 0.50, 0.58 and 2.0 mg/kg. On the basis of residue levels arising from harvest aid uses, the Meeting estimated a maximum residue level for cotton-seed of 2 mg/kg, to replace the previous recommendation, an STMR of 0.34 mg/kg and a highest residue level of 2 mg/kg.

Sunflower seed

In the USA, paraquat is registered for use on sunflower at a maximum rate of 1.14 kg ai/ha with no PHI specified for pre-plant or pre-emergence broadcast or banded over-row application and at a maximum rate of 0.55 kg ai/ha with a 7-day PHI for dessication use.

Trials were conducted with pre-emergence application to sunflowers at 1.12 or 5.6 kg/ha and sampling 41–131 days after application. The residue levels in seeds in four trials conducted in compliance with maximum GAP were < 0.05 mg/kg. When paraquat was applied at five times the maximum recommended rate, the levels were still below the LOQ of 0.05 mg/kg.

In further trials, paraquat was applied as a harvest aid desiccator at 0.28–1.12 kg/ha, and sunflower seeds were harvested 7–21 days after application. The residue levels of paraquat in seeds in trials conducted at maximum GAP were: 0.09, 0.14, 0.15, 0.16 (three), 0.19, 0.22, 0.24, 0.32, 0.35, 0.51, 0.60, 0.74, 0.81 (two) and 0.93 mg/kg. The Meeting used the residue levels arising from harvest aid uses to estimate a maximum residue level for sunflower seed of 2 mg/kg, an STMR of 0.22 mg/kg and a highest residue level of 0.81 mg/kg.

Hops

Residue trials were conducted in Canada and the USA. Paraquat was registered in the USA for use as a directed spray or for suckering and stripping on hops at a maximum rate of 0.55 kg ai/ha in three applications with a 14-day PHI; no more than two applications or applications at no more than 1.5 l/ha were recommended.

In a trial in Canada, a single post-emergence directed application of 1.12 kg ai/ha, which is double the maximum recommended dose, resulted in residue levels of < 0.01 mg/kg in green hops harvested 53 days after application.

In the USA, trials were conducted in the states of Idaho, Oregon and Washington with three post-emergence directed applications of paraquat at 2.8 kg ai/ha. The residue levels of paraquat in dried hops prepared from hops harvested 14 days after the last of three directed application at the maximum GAP rate were 0.05 mg/kg in two trials. At double this rate, the levels in dried hops prepared from green hops harvested 13 or 14 days after the last treatment were below the LOQ of 0.1 mg/kg (0.01 and 0.07 mg/kg). Two applications at higher rates than that of maximum GAP resulted in 0.02 and 0.03 mg/kg in dried hops.

The residue levels in dried hops were 0.05 mg/kg (two). In view of the low levels of residues in the other trials, the Meeting estimated a maximum residue level of 0.1 mg/kg, to replace the previous recommendation, and STMR and highest residue values of 0.05 mg/kg for hops, dry.

Tea, green, black

Residue trials on tea were conducted in India, where paraquat is registered for use for pre-emergence or post-emergence directed application between rows at a maximum rate of 0.75 kg ai/ha in one application, with no PHI specified.

Six trials were conducted at a total application rate of 0.57–2.0 kg ai/ha over 5–6 months. Green tea leaves were harvested 7 or 21 days after blanket application (after the first or last spot application) and processed into black tea, which was analysed. The residue levels of paraquat in black tea from tea plants treated in accordance with GAP in India or at higher rates were almost always below the LOQ of 0.05 mg/kg. In trials conducted in accordance with GAP, the levels in black tea were: <u>< 0.05</u> (three), <u>0.07</u>, 0.09 and 0.12 mg/kg.

In other trials in India, with application rates of 0.05–0.06 kg ai/ha, black tea samples from green tea leaves harvested 5 or 7 days after application contained 0.05 mg/kg (one) or < 0.05 mg/kg. As the application rate was much lower than the maximum, these results were not considered in estimating the maximum residue level.

The Meeting estimated a maximum residue level for teas, green, black of 0.2 mg/kg and an STMR of 0.06 mg/kg.

Animal feedstuffs

Soya forage and hay or fodder

Paraquat is registered for use in Australia, Brazil and the USA for weed control andas a harvest aid on soya beans. In the USA, it is registered for use at a maximum rate of 1.14 kg ai/ha for pre-plant or pre-emergence treatment, not to exceed 1.9 l per season, at a maximum rate of 0.14 kg ai/ha as a post-emergence directed spray with a second and final application 7–14 days later; it can also be used at a maximum rate of 0.28 kg ai/ha with a 15-day PHI as a harvest aid.

The residue levels in forage in trials conducted in the USA in accordance with US GAP were: < 0.025 (12), <u>< 0.05</u> (13), 0.05, 0.06 (four), 0.07, 0.08, 0.15, 0.28 and 1.8 mg/kg, expressed on a dry weight basis.

The Meeting estimated a maximum residue level for soya bean forage (green) of 2 mg/kg, an STMR of 0.05 mg/kg and a highest residue level of 1.8 mg/kg.

The residue levels in hay or fodder in trials conducted in accordance with US GAP were: < 0.025 (five), 0.04, <u>< 0.05</u> (four), 0.05, 0.1, 0.2 and 0.3 mg/kg, on a dry weight basis. The Meeting estimated a maximum residue level for soya bean fodder of 0.5 mg/kg, an STMR of 0.05 mg/kg and a highest residue level of 0.3 mg/kg.

Sugar-beet tops

Trials were conducted on beet and sugar-beet in the United Kingdom and the USA. The residue levels in sugar-beet tops in six trials conducted in accordance with US GAP were < 0.025 mg/kg, on a fresh weight basis. The Meeting estimated a maximum residue level of 0.2 mg/kg and an STMR of 0.11 mg/kg. On the basis of 23% dry matter and a highest residue level on a fresh weight basis of 0.025

mg/kg, the Meeting calculated the highest residue level on a dry weight basis to be 0.11 mg/kg. As there is no code for sugar-beet tops, the maximum residue level was recommended for fodder beet leaves and tops.

Maize forage and fodder

Trials were conducted in Italy and the USA. The residue levels in maize forage in trials in the USA conducted in accordance with US GAP were < 0.025 (eight), 0.09, 0.6, 2 (two) and 3 (two) mg/kg on a dry weight basis. The Meeting estimated a maximum residue level for maize forage of 5 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 3 mg/kg.

The levels of residues in silage were mostly below the LOQ of 0.025 or 0.05 mg/kg, except in one trial in which levels up to 0.04 mg/kg were found.

The residue levels in maize fodder in trials in the USA conducted in accordance with US GAP were: < 0.025 (eight), 0.03, 0.05, 0.06, 0.2, 1, 2 and 6 mg/kg on a dry weight basis. The Meeting estimated a maximum residue level for maize fodder of 10 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 6 mg/kg.

Sorghum forage (green) and straw and fodder, dry

In trials conducted in the USA in accordance with GAP, the residue levels in sorghum forage were: < 0.025 (six), 0.025 (three), 0.04, 0.06 and 0.2 mg/kg. The Meeting estimated a maximum residue level for sorghum forage (green) of 0.3 mg/kg, an STMR of 0.025 mg/kg and a highest residue level of 0.2 mg/kg.

The residue levels in sorghum fodder or hay (whichever gave higher levels) in trials conducted in accordance with GAP were: < 0.025 (four), 0.03, 0.04, 0.05, 0.06 (two), 0.09, 0.1 and 0.2 mg/kg. The Meeting estimated a maximum residue level for sorghum straw and fodder, dry, of 0.3 mg/kg, an STMR of 0.035 mg/kg and a highest residue level of 0.2 mg/kg.

Rice straw and fodder, dry

The Meeting concluded that there were insufficient data for estimating a maximum residue level for rice straw and fodder, dry.

Almond hulls

In three trials conducted in the USA in accordance with GAP, the residue levels in almond hulls were < 0.01 mg/kg. The Meeting estimated maximum residue, STMR and highest residue values of 0.01 mg/kg.

Cotton fodder

The Meeting concluded that there were insufficient data for estimating a maximum residue level for cotton fodder.

Fate of residues during processing

Numerous studies of residue levels after processing conducted in conjunction with supervised trials were submitted. Residue levels found after processing of raw agricultural commodities into animal feedstuffs are described in the section above. Some processed commodities for which maximum residue levels and STMR-Ps were estimated are also described in that section.

In this section, processing factors from raw commodities to processed food products and by-products are discussed. Information on processing was provided for orange, plum, grape, olive, tomato, sugar-beet, maize, sorghum, cotton-seed, sunflower seed and hop. Processing factors could not be reliably calculated for the processing of orange, plum, grape, tomato and sugar-beet because the paraquat residue levels in both raw commodities and processed products were all below the respective LOQs.

Processing factors were calculated for olive (oil), potato (crisps and granules), maize (milling fractions and oil), sorghum (milling fractions), cotton-seed (trash, gin products and oil), sunflower seed (oil) and hop (dried hop and beer) and are shown below.

Commodity	Processing factor	STMR-P (mg/kg)
Olive		0.05
Unwashed olives before processing	0.57	
Washed olives before processing	< 0.43	
Virgin oil	< 0.35	0.018
Refined oil	< 0.35	0.018
Potato		0.02
Wet peel	> 1.9	0.04
Dry peel	> 11	0.22
Peeled potato	0.27[a]	0.01
Crisps	> 0.95	0.02
Granules	> 2.7	0.05
Maize		0.025
Wet milling		
Coarse starch	< 0.25[a]	0.006
Starch	< 0.25[a]	0.006
Crude oil	< 0.25[a]	0.006
Refined oil	< 0.25[a]	0.006
Dry milling		
Germ	0.3[a]	0.0075
Grits	0.25–0.5[a]	0.0006–0.013
Coarse meal	1[a]	0.025
Meal	0.5[a]	0.013
Flour	1.5[a]	0.038
Crude oil	< 0.25[a]	0.006
Refined oil	< 0.05[a]	0.001
Sorghum		0.025
Hulled grain	0.07[a]	0.002
Dry milled bran	3.9	0.097
Coarse grits	0.17	0.004
Flour	0.14	0.004
Wet milled bran	2.3	0.058
Starch	0.07	0.002
Shorts	2.6	0.065
Germ	0.52[a]	0.013
Cotton (from cotton including trash and bolls)		
Fuzzy seed	0.08	0.34
Crude oil	< 0.006	0.01[b]
Meal	< 0.009	0.04
Sunflower seed		0.3
Hulls	2.8[a]	0.64
Meal	0.05[a]	0.01
Oil	< 0.05[a]	0 [b]
Hop		

Commodity	Processing factor	STMR-P (mg/kg)
Dry cones	1.2	0.05 [b]
Beer	< 0.28	0.0001[c]

[a] Based on only one trial.
[b] Estimated from supervised trials
[c] Calculated from a factor of 0.0001

The STMR values for processed products from raw commodities with no residues or for which the results of many supervised trials were available were estimated on the basis of supervised trials.

In four trials in the USA, orange fruit was processed into juice, and the paraquat residues were measured; in all cases, the levels were below the LOQ of 0.01 mg/kg. The residue levels in *orange juice*, including those in trials conducted at rates higher than the maximum application rate, were all below the LOQ of 0.01 mg/kg. The Meeting estimated an STMR-P for orange juice of 0 mg/kg.

No residues of paraquat were found at levels above the LOQ of 0.05 mg/kg in *dried prunes* prepared from plums in two trials. The STMR-P for dried prunes was estimated to be 0 mg/kg.

In a number of trials, olives were processed into oil for analysis of residues. *Olive oil* prepared from olive fruits harvested directly from trees did not contain levels above the LOQ of 0.05 mg/kg. Most samples of olive oil prepared from olive fruits picked up from ground or sprayed directly did not contain paraquat residues at levels above the LOQ; however, in some samples, paraquat residues were found at levels up to 0.06 mg/kg, and fruit harvested at the same time contained 6.8 mg/kg of paraquat residues. As paraquat is unlikely to be transferred into oil owing to its chemical and physical characteristics, its STMR-P is calculated from the processing factor to be 0.018 mg/kg.

Tomato juice and *ketchup* prepared from tomato in trials conducted at an exaggerated rate did not contain paraquat residues at levels above the respective LOQ (0.005 mg/kg for juice and 0.025 mg/kg for ketchup). The STMR values for these products were estimated to be 0 mg/kg.

The residue levels in oil prepared from soya bean treated with paraquat as a harvest aid desiccant in accordance with GAP were below the LOQ of 0.01 mg/kg in five trials. The Meeting estimated an STMR-P for *soya bean oil* of 0.01 mg/kg.

The residue levels in cotton-seed oil, crude, were below the LOQ of 0.01 mg/kg in two trials. The Meeting estimated an STMR-P for *cotton-seed oil* of 0.01 mg/kg and decided to withdraw the previous recommendation for cotton-seed oil, edible.

The residue levels in *sunflower seed oil* obtained from sunflower seed in eight trials conducted at the maximum GAP were < 0.01 mg/kg. Oil obtained from sunflower seed in a trial at double the rate did not contain residues at levels above the LOQ of 0.01 mg/kg. The Meeting estimated an STMR-P for sunflower seed oil of 0 mg/kg and decided to withdraw the previous recommendation for sunflower seed oil, crude and edible.

The residue levels of paraquat in *cotton gin by-product* in trials for harvest aid uses were (including results for cotton harvested 13–17 days after treatment): 5.2, 5.3, 5.9, 6.2, 7.3, 8.0, 9.4, 11, 12 (two), 18, 23, 32, 34 and 69 mg/kg. The Meeting estimated an STMR-P of 10.2 mg/kg for cotton gin by-products.

As *maize flour* contained a higher concentration of paraquat residues than maize grain in one trial, the Meeting estimated a maximum residue level of 0.05 mg/kg.

Residues in animal commodities

Dietary burden of farm animals

The Meeting estimated the dietary burden of paraquat residues for farm animals on the basis of the diets described in Appendix IX to the *FAO Manual* (FAO, 2002), by summing the contribution of each feed to the residue.

Estimated maximum dietary burden of farm animals

Crop	Residue (mg/kg)	Basis	Group	Dry mat-ter (%)	Residue/ Dry matter (mg/kg)	Dietary (mg/kg)		content	Residue (mg/kg)		contribution
						Beef cattle	Dairy cows	Poultry	Beef cattle	Dairy cows	Poultry
Sugar-beet tops	0.025	HR	AV	23	0.11						
Cotton-seed	2	HR	SO	88	2.27	25	25		0.57	0.57	
Cotton gin by-product	10.2	STMR-P		90	11.3	20	20		2.27	2.27	
Maize grain	0.025	HR	GC	88	0.03			80			0.023
Maize forage	3	HR	AF		3	40	50		1.2	1.5	–
Potato, wet peel	0.04	STMR-P	VR	15	0.27						
Sorghum grain	0.025	HR	GC	86	0.03				–		–
Sorgum forage	0.2	HR	AF	–	0.20				–		–
Soya bean	0.41	HR	VD	89	0.46			20			0.092
Soya bean, forage	1.8	HR	AL	–	1.8	15	5		0.27	0.09	–
Soya bean, hay	0.3	HR	AL	–	0.3				–		–
Sunflower meal	0.011	STMR-P	AL	92	0.01	–	–	–	–	–	–
Turnip tops	0.05	HR	VL	30	0.17						
Total									4.30	4.43	0.11

Estimated maximum dietary burden of farm animals

Crop	Residue (mg/kg)	Basis	Group	Dry mat-ter (%)	Residue/ Dry matter (mg/kg)	Dietary (mg/kg)		content	Residue (mg/kg)		contribution
						Beef cattle	Dairy cows	Poultry	Beef cattle	Dairy cows	Poultry
Sugar-beet tops	0.025	STMR	AV	23	0.11						–
Cotton-seed	0.34	STMR	SO	88	0.39	25	25		0.098	0.098	
Cotton gin by-product	10.2	STMR-P		90	11.3	20	20		2.27	2.27	
Maize grain	0.025	STMR	GC	88	0.028			80			0.02
Maize forage	0.025	STMR	AF		0.03	40	50		0.010	0.013	–
Potato wet peel	0.55	STMR-P	VR	15	0.27						
Sorghum grain	0.025	STMR	GC	86	0.03				–		–
Sorgum forage	0.025	STMR	AF		0.03				–		–
Soya bean	0.08	STMR	VD	89	0.09			20			0.02
Soya bean, forage	0.05	STMR	AL		0.05	15	5		0.008	0.003	–
Soya bean, hay	0.05	STMR	AL		0.05				–		–
Sunflower meal	0.011	STMR-P	AL	92	0.01	–	–	–	–		–
Turnip tops	0.025	STMR	VL	30	0.08						
Total									2.39	2.38	0.04

The dietary burdens of paraquat for estimation of MRL and STMR values for animal commodities are: beef cattle, 4.30 and 2.39 ppm; dairy cattle, 4.43 and 2.38 ppm; and poultry, 0.11 and 0.04 ppm.

Feeding studies

In a study of metabolism in goats (see above), one goat was dosed at a rate equivalent to 100 mg/kg of total diet. This is considerably higher than the estimated maximum dietary burden for cattle of 4.30 or 4.43 mg/kg. At 100 mg/kg of diet, the maximum TRRs, expressed in paraquat ion equivalents, found in milk and edible goat tissues were 0.009 mg/kg in milk, 0.12 mg/kg in meat, 0.03 mg/kg in fat, 0.56 mg/kg in liver and 0.74 mg/kg in kidney. In milk, 75.9% of the radiolabel was identified with paraquat.

At the estimated maximum animal burden of 4.30 or 4.43 mg/kg, the levels of paraquat residues were calculated to be < 0.005 mg/kg in milk, 0.005 mg/kg in meat, 0.025 mg/kg in liver and 0.033 mg/kg in kidney. The Meeting estimated maximum residue levels of 0.005* mg/kg for milks, 0.005 mg/kg for mammalian meat and 0.05 mg/kg for edible mammalian offal. These levels replace the previous recommendations for related animal commodities. The STMR values were estimated to be 0.0002 mg/kg for milk, 0.003 mg/kg for meat and 0.0018 mg/kg for edible offal; and the highest residue level values were estimated to be 0.005 mg/kg for meat and 0.033 mg/kg for edible offal.

In the study of metabolism in hens (see above), birds were dosed at a rate equivalent to 30 mg/kg of total diet, which is considerably higher than the estimated maximum dietary burden for poultry of 0.11 mg/kg. At 30 mg/kg diet, the maximum TRRs, expressed in paraquat ion equivalents, found in eggs and edible chicken tissues were 0.18 mg/kg in egg yolk, 0.001 mg/kg in egg albumen, 0.05 mg/kg in meat, 0.05 mg/kg in fat and 0.09 mg/kg in liver.

At the estimated maximum animal burden of 0.11 mg/kg, the maximum residue levels were calculated to be far below the LOQ of 0.005 mg/kg in eggs and other tissues. The Meeting estimated the maximum residue levels to be 0.005* mg/kg for eggs, poultry meat and edible poultry offal. The STMR and highest residue level values were estimated to be 0 for these commodities.

RECOMMENDATIONS

On the basis of the data from supervised trials the Meeting concluded that the residue levels listed below are suitable for establishing maximum residue limits and for IEDI and IESTI assessment.

Plant commodities and animal commodities

Definition of the residue for compliance with MRLs: paraquat cation
Definition of the residue for estimation of dietary intake: paraquat cation

Commodity		Recommended MRL mg/kg		STMR/ STMR-P[1)] mg/kg	HR/HR-P[1)] mg/kg
CCN	Name	New	Previous		
AM 0660	Almond hulls	0.01 (*)			
FI 0030	Assorted tropical fruits – inedible peel (except passion fruit)	0.01 (*)		0.01	0.01
FB 0018	Berries and other small fruits	0.01 (*)		0	0
MO 1280	Cattle kidney	W	0.5		
FC 0001	Citrus fruits	0.02	-	0.01	0.02
JF 0004	Orange juice			0	
SO 0691	Cotton seed	2	0.2	0.34	
OC 0691	Cotton seed oil, crude			0.01	
OR 0691	Cotton seed oil, Edible	W	0.05 (*)		
MO 0105	Edible offal (mammalian)	0.05		0.018	0.033
MO 0097	Edible offal of cattle, pigs & sheep	W	0.05 (*)		
PE 0112	Eggs	0.005 (*)	0.01 (*)	0	0
AV 1051	Fodder beet leaves or tops	0.2 (dry wt)			
VC 0045	Fruiting vegetables, cucurbits	0.02		0	0
VO 0050	Fruiting vegetables, other than cucurbits	0.05		0.01	0.04
JF 0448	Tomato juice			0	
	Ketchup			0	

Commodity		Recommended MRL mg/kg		STMR/ STMR-P[1)] mg/kg	HR/HR-P[1)] mg/kg
CCN	Name	New	Previous		
DH 1100	Hops, Dry	0.1	0.2	0.05	0.05
	Beer			0.0001	
VL 0053	Leafy vegetables	0.07		0.025	0.05
GC 0645	Maize	0.03	0.1	0.025	
CF 1255	Maize flour	0.05		0.038	
	Maize germ			0.0075	
	Maize grits/meal			0.013	
OC 0645	Maize oil, crude			0.006	
	Corn starch			0.006	
AS 0645	Maize fodder	10 (dry wt.)			
AF 0645	Maize forage	5 (dry wt.)			
MM 0095	Meat (from mammalian other than marine mammals)	0.005		0.003	0.005
MM 0097	Meat of cattle, pigs & sheep	W	0.05 (*)		
ML 0106	Milks	0.005*	0.01 (*)	0.0002	
FT 0305	Olives	0.1	1	0.05	0.1
OC 0305	Olive oil, virgin			0.018	
FI 0351	Passion fruit	W	0.2		
MO 1284	Pig kidney	W	0.5		
FP 0009	Pome fruits	0.01 (*)	-	0	0
VR 0589	Potato	W	0.2		
	Potato crisps			0.02	
	Potato granules			0.05	
PO 0111	Poultry, Edible offal of	0.005 (*)		0	0
PM 0110	Poultry meat	0.005 (*)		0	0
VD 0070	Pulses	0.5		0.08	
GC 0649	Rice	W	10		
CM 1205	Rice, Polished	W	0.5		
VR 0075	Root and tuber vegetables	0.05		0.02	0.05
MO 1288	Sheep kidney	W	0.5		
GC 0651	Sorghum	0.03	0.5	0.025	
	Sorghum flour			0.004	
	Sorghum germ			0.013	
AF 0651	Sorghum forage (green)	0.3			
AS 0651	Sorghum straw and fodder	0.3			
VD 0541	Soya bean (dry)	W	0.1		
AL 0541	Soya bean fodder	0.5 (dry wt.)			
AL 1265	Soya bean forage (green)	2 (dry wt.)			
OC 0541	Soya bean oil, crude			0.01	
FS 0012	Stone fruits	0.01 (*)		0	0
DF 0014	Prune			0	
SO 0702	Sunflower seed	2	2	0.23	
OC 0702	Sunflower seed oil, Crude	W	0.05 (*)	0	
OR 0702	Sunflower seed oil, Edible	W	0.05 (*)		
DT 1114	Tea, green, black	0.2		0.06	
TN 0085	Tree nuts	0.05		0.01	0.05
AO1 0002	Vegetables (except as otherwise listed)	W	0.05 (*)		

DIETARY RISK ASSESSMENT

Long-term intake

The IEDIs were calculated for the five GEMS/Food regional diets from the STMR values for fruit, vegetables, maize, sorghum, cotton-seed, sunflower, hops, tea and animal commodities and the STMR-P values for their processed products, as estimated by the current Meeting (Annex 3 of the Report). The ADI is 0–0.005 mg/kg bw, and the calculated IEDIs were 2–5% of the ADI. The Meeting concluded that the intake of residues of paraquat resulting from uses considered by the current JMPR was unlikely to present a public health concern.

Short-term intake

The IESTIs of paraquat by the general population and by children were calculated for commodities for which STMR or STMR-P values had been estimated by the current Meeting when information on consumption was available (Annex 4 of the Report). The ARfD is 0.006 mg/kg; the calculated IESTIs for children up to 6 years range from 0 to 50% and those for the general population from 0 to 20% of the ARfD. The Meeting concluded that the short-term intake of residues of paraquat from uses considered by the current Meeting was unlikely to present a public health concern.

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Paraquat (Ref: PP 148)

(Also known as: orthoparaquat; PP 910)

Last updated: 25/02/2021

PPDB

SUMMARY

Data alerts

The following alerts are based on the data in the tables below. An absence of an alert does not imply the substance has no implications for human health, biodiversity or the environment but just that we do not have the data to form a judgement.

Environmental fate	Ecotoxicity	Human health
🔴	🔴	🟡

GENERAL INFORMATION

Descripon	A herbicide used to control common weeds in a wide range of agricultural and amenity situations
Example pests controlled	Broad-leaved weeds including cocksfoot; Grasses including wild oats, Yorkshire fog grass, ryegrass, fescue
Example applicaons	Rice; Lucerne; Beans & peas; Hops; Vineyards; Potaoes; Non-cropped areas such as roadways, paths
Efficacy & acvity	-
Availability status	Current
Introducon & k ey dates	1962

UK regulatory status

UK COPR regulatory status	Not approved
Date COPR inclusion expires	Expired
UK LERAP status	Not applicable

EC Regulaon 1107/2009 (r epealing 91/414)

EC Regulaon 1107/2009 s tatus	Not approved
Dossier rapporteur/co-rapporteur	UK
Date EC 1107/2009 inclusion expires	Expired
EU Candidate for substuon (CfS)	Not applicable
Listed in EU database	Yes
Approved for use (✓) under EC 1107/2009 in the following EU Member States	

AT	BE	BG	CY	CZ	DE	DK	EE	EL
ES	**FI**	**FR**	**HR**	**HU**	**IE**	**IT**	**LT**	**LU**
LV	**MT**	**NL**	**PL**	**PT**	**RO**	**SE**	**SI**	**SK**

Also used in

Also used in	Australia, USA, Canada, Mexico, Brazil, Japan, India, China, Indonesia, Thailand, New Zealand

Chemical structure

Isomerism	-
Chemical formula	$C_{12}H_{14}N_2$
Canonical SMILES	C[N+]1=CC=C(C=C1)C2=CC=[N+](C=C2)C
Isomeric SMILES	No data
Internaonal Chemic al Idenfier k ey (InChIKey)	INFDPOAKFNIJBF-UHFFFAOYSA-N
Internaonal Chemic al Idenfier (InChI)	InChI=1S/C12H14N2/c1-13-7-3-11(4-8-13)12-5-9-14(2)10-6-12/h3-10H,1-2H3/q+2
2D structure diagram/image available?	Yes

General status

Pescide type	Herbicide
Substance group	Bipyridylium
Minimum acv e substance purity	-
Known relevant impuries	EU dossier - free 4,4¢-bipyridyl
Substance origin	Synthetic
Mode of acon	Broad-spectrum, non-residual activity with contact and some desiccant action. Photosystem I (electron transport) inhibitor.
CAS RN	4685-14-7
EC number	217-615-7
CIPAC number	56
US EPA chemical code	-
PubChem CID	15939
Molecular mass	186.25
PIN (Preferred Idenfic aon Name)	-
IUPAC name	1,1'-dimethyl-4,4'-bipyridinium
CAS name	1,1'-dimethyl-4,4'-bipyridinium
Other status informaon	PAN Dirty Dozen; Chemical subject to PIC regulations
Relevant Environmental Water Quality Standards	-
Herbicide Resistance Classificaon (HRAC)	D
Herbicide Resistance Classificaon (WSSA)	22
Inseccide R esistance Classificaon (IRAC)	Not applicable

Fungicide Resistance Classificaon (FRAC)	Not applicable
Examples of recorded resistance	*Lolium rigidum*
Physical state	Colourless to pale yellow crystalline solid
Related substances & organisms	• diquat dibromide

Formulaons

Property	Value
Example manufacturers & suppliers of products using this acv e now or historically	• AgriGuard Paraquat
Example products using this acv e	• AgriGuard • Clayton • Syngenta
Formulaon and applic aon de tails	Often supplied as a soluble concentrate that is mixed with water and used as a spray

ENVIRONMENTAL FATE

Property		Value	Source; quality score; and other informaon	Interpretaon
Solubility - In water at 20 °C (mg l^{-1})		620000	A5	High
Solubility - In organic solvents at 20 °C (mg l^{-1})		143000	A5 Methanol	-
		100	A5 Acetone	-
		100	A5 Toluene	-
		100	A5 Hexane	-
Melng poin t (°C)		-	-	-
Boiling point (°C)		-	-	-
Degradaon poin t (°C)		-	-	-
Flashpoint (°C)		-	-	-
Octanol-water paron coefficient at pH 7, 20 °C	**P**	3.16×10^{-05}	Calculated	-
	Log P	-4.5	A5	Low
Bulk density (g ml^{-1})		1.5	A5	-
Dissociaon c onstant pKa) at 25 °C		Not applicable	A5	-
		No dissociation		
Vapour pressure at 20 °C (mPa)		0.01	A3	Low volatility
Henry's law constant at 25 °C (Pa m^3 mol^{-1})		4.00×10^{-12}	A5	Non-volatile
Maximum UV-vis absorpon L mol^{-1} cm^{-1}		290nm	A5	-
Surface tension (mN m^{-1})		-	-	-

Degradaon

Property		Value	Source; quality score; and other informaon	Interpretaon
General biodegradability		-		
Soil degradaon (days) (aerobic)	DT_{50} (typical)	3000	A5	Very persistent
	DT_{50} (lab at 20 °C)	5000	Y3	Very persistent
	DT_{50} (field)	2800	A5	Very persistent
	DT_{90} (lab at 20 °C)	-	-	-
	DT_{90} (field)	-	-	-
	DT_{50} modelling endpoint	-	-	-
	Note	Field studies DT_{50} range 7-8 years (UK)		
Dissipaon r ate RL_{50} on plant matrix	Value	-	-	-
	Note	-		
Dissipaon r ate RL_{50} on and in plant matrix	Value	-	-	-
	Note	-		
Aqueous photolysis DT_{50} (days) at pH 7	Value	Stable	A5	Stable
	Note	-		
Aqueous hydrolysis DT_{50} (days) at 20 °C and pH 7	Value	Stable	A5	Stable
	Note	Stable pH 5 to pH 9, 30 days at 25 and 40 °C		
Water-sediment DT_{50} (days)		Stable	Q2	Stable
Water phase only DT_{50} (days)		10	Q2	Moderately fast

Soil adsorpon and mobility

Property		Value	Source; quality score; and other informaon	Interpretaon
Linear	K_d	-	A3	Non-mobile
	K_{oc}	1000000		
	Notes and range	-		
Freundlich	K_f	-	-	-
	K_{foc}	-		
	$^1/_n$	-		
	Notes and range	-		
pH sensivity		-		

Fate indices

Property		Value	Source; quality score; and other informaon	Interpretaon
GUS leaching potenal inde x		-6.89	Calculated	Low leachability
SCI-GROW groundwater index (µg l^{-1}) for a 1 kg ha^{-1} or 1 l ha^{-1} applicaon rate	Value	5.35 X 10^{-03}	Calculated	-
	Note	Estimated concentrations of chemicals with Koc values greater than 9995 ml g^{-1} are beyond the scope of the regression data used in SCI-GROW development. If there are concerns for such chemicals, a higher tier groundwater exposure assessment should be considered, regardless of the concentration returned by SCI-GROW		
Potenal f or parcle bound transport index		High	Calculated	-
Potenal f or loss via drain flow		Non-mobile	Calculated	-

ECOTOXICOLOGY

Property		Value	Source; quality score; and other informaon	Interpretaon
Bio-concentraon factor	BCF (l kg^{-1})	Low risk	A5 Based on LogP < 3	Low risk
	CT_{50} (days)	-		-
Mammals - Acute oral LD_{50} (mg kg^{-1})		110	G4 Rat	Moderate
Mammals - Short term dietary NOEL	(mg kg^{-1})	-	A5 Rat	-
	(ppm diet)	> 100		-
Mammals - Chronic 21d NOAEL (mg kg^{-1} bw d^{-1})		2.5	A5 Unknown species Lowest relevant reproductive NOAEL/NOEL	High
Birds - Acute LD_{50} (mg kg^{-1})		35	A4 Unknown species	High
Birds - Short term dietary (LC_{50}/LD_{50})		698 mg kg $feed^{-1}$	A4 unknown species	-
Birds - Chronic 21d NOEL (mg kg^{-1} bw d^{-1})		-	-	-
Fish - Acute 96 hour LC_{50} (mg l^{-1})		19	A5 *Oncorhynchus mykiss*	Moderate
Fish - Chronic 21 day NOEC (mg l^{-1})		> 8.0	P3 *Clarias gariepinus*	Moderate
Aquac in vertebrates - Acute 48 hour EC_{50} (mg l^{-1})		4.4	A5 *Daphnia magna*	Moderate
Aquac in vertebrates - Chronic 21 day NOEC (mg l^{-1})		0.12	A5 *Daphnia magna*	Moderate
Aquac crus taceans - Acute 96 hour LC_{50} (mg l^{-1})		-	-	-
Sediment dwelling organisms - Acute 96 hour LC_{50} (mg l^{-1})		-	-	-
Sediment dwelling organisms - Chronic 28 day NOEC, stac, w ater (mg l^{-1})		0.367	A5 *Chironomus riparius*	Moderate

Property		Value	Source; quality score; and other informaon	Interpretaon
Sediment dwelling organisms - Chronic 28 day NOEC, sediment (mg kg^{-1})		> 100	A5 *Chironomus riparius*	Low
Aquac plan ts - Acute 7 day EC_{50}, biomass (mg l^{-1})		0.037	A5 *Lemna gibba*	Moderate
Non-target plants		-	-	-
		-	-	-
Algae - Acute 72 hour EC_{50}, growth (mg l^{-1})		0.00023	A5 *Raphidocelis subcapitata*	High
Algae - Chronic 96 hour NOEC, growth (mg l^{-1})		-	-	-
Honeybees (*Apis* spp.)	Contact acute LD_{50} (worst case from 24, 48 and 72 hour values - µg bee^{-1})	9.26	A5	Moderate
	Oral acute LD_{50} (worst case from 24, 48 and 72 hour values - µg bee^{-1})	> 9.06	A5	Moderate
	Unknown mode acute LD_{50} (worst case from 24, 48 and 72 hour values - µg bee^{-1})	-	-	-
Bumblebees (*Bombus* spp.)	Contact acute LD_{50} (worst case from 24, 48 and 72 hour values - µg bee^{-1})	-	-	-
		-		
	Oral acute LD_{50} (worst case from 24, 48 and 72 hour values - µg bee^{-1})	-	-	-
		-		
Mason bees (*Osmia* spp.)	Contact acute LD_{50} (worst case from 24, 48 and 72 hour values - µg bee^{-1})	-	-	-
	Oral acute LD_{50} (worst case from 24, 48 and 72 hour values - µg bee^{-1})	-	-	-

Property		Value	Source; quality score; and other informaon	Interpretaon
Other pollinators (1)	Acute LD_{50} (worst case from 24, 48 and 72 hour values - µg insect^{-1})	-	-	-
	Mode of exposure	-		
Other pollinators (2)	Acute LD_{50} (worst case from 24, 48 and 72 hour values - µg insect^{-1})	-	-	-
	Mode of exposure	-		
Earthworms - Acute 14 day LC_{50} (mg kg^{-1})		> 1000	A5 *Eisenia foetida*	Low
Earthworms - Chronic NOEC, reproducon (mg kg^{-1})		-	-	-
Other soil macro-organisms	Acute LC_{50} (mg kg^{-1})	-	-	-
	Chronic NOEC (mg kg^{-1})	-	-	-
Other arthropod (1)	LR_{50} g ha^{-1}	-	-	-
	% Effect	0	Mortality [Dose: 0.01 kg ha^{-1}] A5 *Pardosa spp.* adult	-
Other arthropod (2)	LR_{50} g ha^{-1}	-	-	-
	% Effect	0	Mortality [Dose: 0.01 kg ha^{-1}] A5 *Aleochara bilineata* adult	-
Soil micro-organisms		Nitrogen mineralisation: No significant adverse effect Carbon mineralisation: No significant adverse effect	A5 Dose: 720 kg ha^{-1} 1 year	-
Mesocosm study data	NOEAEC mg l^{-1}	-	-	-
	NOEAEC mg l^{-1}	-	-	-

HUMAN HEALTH AND PROTECTION

General

Property	Value	Source; quality score; and other informaon	Interpretaon
Threshold of Toxicological Concern (Cramer Class)	High (class III)	-	-

Property		Value	Source; quality score; and other informaon	Interpretaon
Mammals - Acute oral LD_{50} (mg kg^{-1})		110	G4 Rat	Moderate
Mammals - Dermal LD_{50} (mg kg^{-1} body weight)		200	A4 Rat	-
Mammals - Inhalaon L C_{50} (mg l^{-1})		0.6	A5 Rat	-
Other Mammal toxicity endpoints		-	-	-
ADI - Acceptable Daily Intake (mg kg^{-1} bw day^{-1})		0.004	A5 Dog SF=100	-
ARfD - Acute Reference Dose (mg kg^{-1} bw day^{-1})		0.005	A5 Dog SF=100	-
AAOEL - Acute Acceptable Operator Exposure Level (mg kg^{-1} bw day^{-1})		-	-	-
AOEL - Acceptable Operator Exposure Level - Systemic (mg kg^{-1} bw day^{-1})		0.0004	A5 Dog 90 day SF=100	-
Dermal penetraon s tudies (%)		0.5	A5	-
Dangerous Substances Direcv e 76/464		[No unacceptable risks to bystanders identified]	-	-
Exposure Routes	Public	No unacceptable risks to operators or other workers identified		
	Occupaonal	-		
MRLs	European	EU MRL pescide da tabase		
	Notes	-		
Drinking Water Standards		-	-	-
Drinking Water MAC (µg l^{-1})		-	-	-

Health issues

Specific human health issues			
	Carcinogen	Genotoxic	Endocrine disruptor
	?	A0; B0; C0; D0; E1	X
	Reproducon / development effects	Acetyl cholinesterase inhibitor	Neurotoxicant
	?	X	X
	Respiratory tract irritant	Skin irritant	Skin sensiser
	✓	✓	No data found
	Eye irritant	Phototoxicant	
	✓	No data found	
General human health issues	Potential liver, kidney, stomach, intestine and respiratory system toxicant		

Handling issues

Property	Value and interpretaon

Property	Value and interpretaon
General	Not explosive or oxidising IMDG Transport Code is usually 6.1
CLP classificaon 2013	Health: H301, H311, H315, H319, H330, H335, H372 Environment: H400, H410
EC Risk Classificaon	T+ - Very toxic: R26 T - Toxic: R24/25, R48/25 Xi - Irritant: R36/37/38 N - Dangerous for the environment: R50, R53
EC Safety Classificaon	S1/2, S22, S28, S36/37/39, S45, S60, S61
WHO Classificaon	II (Moderately hazardous)
UN Number	2781
Waste disposal & packaging	Packaging Group II (medium danger)

TRANSLATIONS

Language	Name
English	paraquat
French	paraquat
German	Paraquat
Danish	paraquat
Italian	paraquat
Spanish	paracuat
Greek	-
Polish	parakwat
Swedish	-
Hungarian	-
Dutch	-

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