Australian Government

Australian Pesticides and Veterinary Medicines Authority

Paraquat

Final Review Technical Report

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Preface

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is the independent Commonwealth statutory authority with responsibility for the regulation of agricultural and veterinary chemicals in Australia. Its statutory powers are provided in the Agricultural and Veterinary Chemicals Code (the Agvet Code), which is scheduled to the *Agricultural and Veterinary Chemicals Code Act 1994*.

About this document

This Technical Report is intended to provide an overview of the assessments that have been conducted by the APVMA and of the specialist advice received. It has been deliberately presented in a manner that is likely to be informative to the widest possible audience.

Further information

Further information can be obtained via the contact details provided below. More details on the chemical review process can be found on the APVMA website: www.apvma.gov.au

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Executive summary

Key outcomes

- Paraquat products can continue to be registered for use in Australia but require strengthened risk mitigation measures to protect worker health and safety, and revised instructions for use to lower environmental exposure to protect the safety of Australian native birds and mammals.
- The risk assessment recommendations result in a substantial reduction in the number of situations where paraquat may be used, but range of uses remain supported, including use of optical spot spraying technologies in certain situations.

Overview

Paraquat is a non-selective contact herbicide used across a wide range of agricultural settings. The APVMA has completed a reconsideration of paraquat to determine whether the active constituent approvals, product registrations and labels continue to meet the statutory criteria for safety, efficacy, trade and labelling. The review included risk assessments covering chemistry, toxicology, worker health and safety, residues and trade, and environmental safety.

Paraquat and diquat have been registered in Australia since 1964 and were placed under reconsideration in 1997 under the Existing Chemicals Review Program. At the time of publication of the final report, paraquat was present in 119 registered products, including paraquat-only products, paraquat/diquat co-formulations and a small number of paraquat/amitrole products.

The APVMA published proposed regulatory decisions on the reconsideration of paraquat, and the related chemical diquat, on 30 July 2024 and invited public comment on the proposed decisions in a consultation that commenced on 30 July 2024 and closed 29 October 2024. 171 submissions were received. The APVMA has considered all submissions received and, where relevant, the risk assessments presented in this report have been revised to include the new information that was provided. Details of the submissions received and the APVMA's consideration of those submissions is published separately.

Main findings

The key driver of the reconsideration recommendations are risks to terrestrial vertebrates. These risks relate primarily to acute dietary exposure for birds, and to a lesser extent mammals, foraging in treated areas. As a result, limited application rates, or removal of instructions for use in some situations entirely, are recommended to prevent exposure from exceeding acceptable levels.

Worker health and safety assessments recommended that risks to the safety of occupational users can be managed through strengthened personal protective equipment requirements, the use of closed mixing and loading systems, enclosed cab requirements for broadacre boom application, revised re-entry intervals and updated label statements. Backpack sprayer use was not supported for paraquat-only or paraquat/diquat products.

A comprehensive review of studies related to Parkinson's disease that were submitted to the APVMA following publication of the proposed regulatory decisions on the reconsideration did not find convincing evidence of a direct causal association between paraquat exposure from approved pesticidal uses and Parkinson's disease. Details of this assessment are published separately.

Residues and trade assessments, which consider the findings of the environment, toxicology and worker health and safety assessments, support continued use of paraquat in situations that were also supported by those other risk assessments. These assessments also concluded that dietary exposure from treated commodities is expected to be acceptable for public health. Minor changes to some withholding periods and updated Trade Advice statements were recommended.

Overall, the reconsideration assessments support continuation of paraquat approvals and registrations only where strengthened risk mitigation measures, revised labels, and any necessary product-specific changes are implemented to ensure the products continue to meet the legislative criteria.

1 Introduction

Paraquat is a non-selective contact herbicide belonging to the bipyridinium class of compounds which also includes the related herbicide diquat. Paraquat and diquat have been registered for use in Australia since 1964. Both compounds belong to the herbicide mode of action group 22[1] and share a mode of herbicidal action which involves the inhibition of photosynthesis (specifically photosystem I) resulting in generation of hydroxyl radicals and other reactive oxygen species leading to lipid peroxidation and membrane damage. Plants die rapidly after treatment and exposure to light.

1.1 Purpose of review

Paraquat and the related bipyridinium herbicide diquat were placed under reconsideration by the APVMA (then NRA) in the third cycle of the Existing Chemicals Review Program, in a notice published in the NRA Gazette on 2 December 1997.

The reconsideration covers all aspects of the active constituent approval, product registration and label approval to evaluate whether the continuing use of paraquat:

- would not be an undue hazard to the safety of people exposed to it during its handling or people using anything containing its residues
- would not be likely to have an effect that is harmful to human beings
- would not be likely to have an unintended effect that is harmful to animals, plants or things or to the environment
- would not unduly prejudice trade or commerce between Australia and places outside Australia
- would be effective in accordance with the instructions for its use

The following aspects of active constituent approvals and product registrations for paraquat have been assessed:

- Toxicology, including a detailed assessment of the potential for neurotoxic effects
- Worker health and safety
  - Risks arising from exposure during handling and application
  - Re-entry exposure risks
  - Determination of appropriate personal protective clothing requirements
- Residues and trade:
  - Residues in treated produce arising from application in accordance with label instructions
  - Maximum Residue Limits (MRLs) to underpin the assessment of consumer safety and trade risk

[1]Mode of Action tables maintained by Croplife are available at the link below (accessed May 2026)
https://www.croplife.org.au/resources/programs/resistance-management/herbicide-moa-table-4/

  - Determination of dietary exposure resulting from the consumption of produce treated with paraquat
- Environmental safety
- Spray drift

The APVMA has also considered information pertaining to chemistry (impurities of toxicological concern).

Although paraquat and diquat are structurally related, their relative risk to human and environmental safety, and trade, have been assessed separately.

A summary of the combined risk assessment outcomes for each use pattern, and whether it is supported for continued approval, is presented in Appendix A.

1.2 Product claims, use patterns and mode of action

Paraquat is an active constituent in 119 products registered for use in Australia by the APVMA, including 8 that have been registered following preparation of the APVMA's proposed regulatory decisions which were published on 30 July 2024, which will be dealt with outside the reconsideration process. These products can be divided into 3 groups based on the presence of a second active constituent, as indicated in the table below. Paraquat products containing paraquat as the only active constituent (group 1 below), products that contain both paraquat and diquat (group 2 below) and products that contain paraquat and amitrole (group 3 below). This report includes complete assessments of the risk posed by products containing paraquat as the sole active constituent, and products containing both paraquat and diquat. Products containing paraquat and amitrole have been reassessed with respect to the risk posed by paraquat only, as amitrole has not been placed under reconsideration.

These 3 groups can be further divided based on the concentration of paraquat and the secondary active constituent as shown in Table 1. Paraquat products are used as herbicides against broadleaf and grass weeds in a variety of situations, including treatment of weeds in seed beds before sowing, post-emergence inter-row weed control and pre-harvesting operations of a number of crops. Paraquat products often include instructions for use as a tank-mix with diquat or other herbicides to improve efficacy against particular weed species (e.g. capeweed), or to provide residual activity (e.g. diuron used for control of annual grasses and broadleaf weeds in lucerne (*Medicago sativa*)). Paraquat is also used as a crop desiccant, for hay freezing, accelerating the drying of seeds and desiccating weeds to facilitate crop harvesting. A detailed list of use patterns considered in this assessment is provided in Appendix A – Summary of assessment outcomes.

Current permits for use of paraquat are not within the scope of this reconsideration.

Table 1: Paraquat product groups within scope of reconsideration

Group	Active constituent(s)	Active constituent concentration
1a (51 products)	Paraquat	250 g/L paraquat
1b (8 products)		300 g/L paraquat
1c (1 products)		330 g/L paraquat
1d (1 product)		334 g/L paraquat

1e (1 product) 1f (12 products)		350 g/L paraquat 360 g/L paraquat
2 (35 products)	Paraquat/diquat	135 g/L paraquat; 115 g/L diquat
3a (1 product) 3b (1 products)	Paraquat/amitrole	250 g/L paraquat; 10 g/L amitrole 300 g/L paraquat; 12 g/L amitrole

2 Chemistry

2.1 Active constituent

Paraquat dichloride in its pure form is a colourless to off-white crystalline solid with a slightly ammoniacal odour. Paraquat dichloride is an extremely hygroscopic material and is commercially supplied as a technical concentrate (manufacturing concentrate) consisting of an aqueous solution with a typical concentration of 50% w/v (500 g/L). As well as being extremely soluble in water, paraquat dichloride is soluble in methanol while being practically insoluble in most other organic solvents and has an extremely low octanol-water partition coefficient that will not partition into fatty or other hydrophobic matrices. It is generally stable to hydrolysis and aqueous photolysis. Further information about the identity and physicochemical properties of paraquat are provided in Table 2 and 3. There are currently 18 active constituent approvals for paraquat dichloride listed in Table 4 below.

Table 2: Nomenclature and structural formula of the active constituent paraquat dichloride

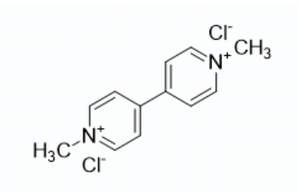
Common name (ISO):	Paraquat dichloride. Paraquat (ISO approved name for the cation)
IUPAC name:	1,1'-dimethyl-4,4'-bipyridinium dichloride
Chemical Abstracts name:	1,1'-dimethyl-4,4'-bipyridinium dichloride
CAS registry number:	1910-42-5 (dichloride) 4685-14-7 (cation)
Molecular formula:	$C_{12}H_{14}Cl_2N_2$ (dichloride) $C_{12}H_{14}N_2$ (cation)
Molecular weight:	257.2 $gmol^{-1}$ (dichloride) 186.3 $gmol^{-1}$ (cation)
Structural formula:	

Table 3: Key physicochemical properties of the active constituent paraquat dichloride

Appearance	Paraquat dichloride technical substance is a colourless to off-white hygroscopic crystals with a slightly ammoniacal odour. Paraquat dichloride is supplied commercially as an aqueous solution (technical concentrate) typically containing 500 g/L paraquat dichloride
Meting point	Approx. 340°C (decomposes)
Density	1.12-1.15 g/mL as dichloride salt. At room temperature paraquat dichloride is a solid. The technical concentrate (manufacturing concentrate) is usually formulated as an aqueous solution
Solubility in water	620 g/L (20-25 °C)
Organic solvent solubility (20 °C)	143 g/L in methanol, <0.1 g/L in acetone, dichloromethane, toluene, ethyl acetate and hexane
Octanol/water partition coefficient (Log Kow)	-4.5 at 20°C (log K_{ow})
Vapour pressure	5.3 X 10^{-4} Pa (25°C)
Stability	Stable in neutral and acidic media but readily hydrolysed in alkaline media. Photochemically decomposed by UV irradiation in aqueous solution (75% loss in 96 h in UV light).
Henry's law constant (calculated)	<4 × 10^{-9} Pa.m^3mol^{-1}
Hydrolysis (DT50, 25 °C)	>30 days (pH 5, 7, 9; 40 °C)
Aqueous photolysis (DT50)	Stable to aqueous photolysis

2.1.1 Active Constituent Standards

The *Agricultural and Veterinary Chemicals Code (Agricultural Active Constituents) Standards 2022* (Agricultural Active Constituents Standards 2022) entry for paraquat dichloride (APVMA, 2022) is consistent with the specification for paraquat dichloride provided in the *Food and Agriculture Organization of The United Nations (FAO) Specifications for Plant Protection Products* *(FAO, 2021)*. The minimum purity for paraquat dichloride on a dry weight basis is 920 g/kg, with maximum levels for two toxicologically significant impurities of total terpyridines at 0.001 g/kg (1.0 ppm) maximum and 4,4'-bipyridyl: 1.0 g/kg (1000 ppm) maximum. Paraquat dichloride technical concentrate (manufacturing concentrate) shall contain a lower limit of 500 g/L paraquat dichloride, which corresponds nominally to 442 g/kg paraquat dichloride (320 g/kg paraquat ion). When determined, the average measured content shall not differ from that declared by more than ± 25 g/L, which corresponds to ± 5% on a g/kg basis. Other important notes included in the paraquat dichloride standard include:

Note 1:

The product must not be allowed to come into direct contact with metal. If metal is used, containers must be lined with suitable polymeric material, or the internal surfaces treated to prevent corrosion of the container and/or deterioration of the contents.

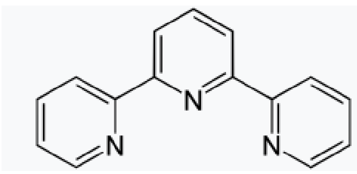
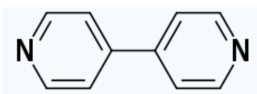
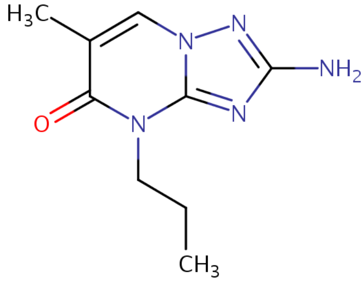
Note 2:

An effective emetic, having the following characteristics, must be incorporated into the Technical Concentrate (TK).

- It must be rapidly absorbed (more rapidly than paraquat) and be quick acting. Emesis must occur in about half an hour in at least 50% of cases.
- It must be an effective (strong) stimulant of the emetic centre of the brain, to produce effective emesis. The emetic effect should have a limited 'action period', of about 2 to 3 hours, to allow effective treatment of poisoning.
- It must act centrally on the emetic centre in the brain.
- It must not be a gastric irritant because, as paraquat is itself an irritant, this could potentiate the toxicity of paraquat.
- It must be toxicologically acceptable. It must have a short half-life in the body (to comply with the need for a limited action period).
- It must be compatible with, and stable in, the paraquat formulation and not affect the herbicidal efficacy or occupational use of the product.

To date, the only compound found to meet these requirements is 2-amino-4,5-dihydro-6-methyl-4-propyl-s-triazole-(1,5a)pyrimidin-5-one (PP796). PP796 must be present in the TK at not less than 0.8 g/L.

Figure 1: Related impurities and other compounds specified in the paraquat dichloride active standard

		
Terpyridines (2,2';6',2"-terpyridine)	4,4′-Bipyridine, CAS number 553-26-4	2-amino-4,5-dihydro-6-methyl-4-propyl-s-triazole-(1,5a)pyrimidin-5-one (PP796), CAS number 27277-00-5

2.1.2 Statutory considerations under the safety criteria – active constituents

Under section 5A of the Agvet Code, when determining whether an active constituent satisfies the safety criteria, the APVMA must (amongst other matters) have regard to:

- The method by which the active constituent is or is proposed to be manufactured.
- The extent to which the active constituent will contain impurities.
- Whether an analysis of the active constituent has been carried out and the results of any such analysis.
- whether the constituent conforms, or would conform, to any standard made for the constituent under section 6E to the extent that the standard relates to matters covered be the safety criteria.
- Any other relevant matters.

The manufacturing processes of each source of paraquat dichloride were assessed at the time of approval along with batch analyses of the chemical composition, including the levels of impurities.

Paraquat dichloride is generally manufactured using 4,4'-bipyridyl as a starting material or intermediate in the process. As 4,4'-bipyridyl is of toxicological significance, a maximum limit has been specified for this compound in paraquat dichloride technical concentrate in both the Agricultural and Veterinary Chemicals Code (Agricultural Active Constituents) Standards 2022 (Agricultural Active Constituents Standard 2022) and the FAO specification. Terpyridines, which are also of toxicological significance, can be formed as a byproduct during the manufacture of 4,4'-bipyridyl and can therefore be present in paraquat dichloride technical concentrates. Again, a maximum limit has been specified for this compound in paraquat dichloride technical concentrate in both the APVMA standard and the FAO specification.

Based on the information considered at the time of approval, including the manufacturing process, other impurities of toxicological significance are not expected to be present in approved sources of paraquat dichloride technical concentrate.

The APVMA standard for paraquat dichloride technical concentrate was revised in 2013 to align with the FAO specification, this included revising the limits for 4,4'-bipyridyl and terpyridines and the additional requirement to include an emetic due to the high acute toxicity of paraquat dichloride. Sources of paraquat dichloride technical concentrate approved following promulgation of the revised APVMA standard have been assessed against, and determined to comply with, that standard (69493, 87171, 89426 and 91420). Sources of paraquat dichloride technical concentrate approved prior to revision of the standard are required to meet the standard, but in general, have not provided data to demonstrate that they comply with the revised standard, noting that active constituent approvals 44249 and 55966, have demonstrated compliance with the Active constituent standard, but do not list all relevant impurities in their current declarations of composition.

Based on the information provided and the assessment conducted at the time of approval, in respect of the chemistry-related matters in the section 5A safety criteria, it is recommended that APVMA remains satisfied in respect of the manufacturing method for all approved paraquat dichloride active constituents.

It is recommended that sources of paraquat dichloride technical concentrate approved after the 2013 revision of the active constituent standard (69493, 87171, 89426 and 91420) satisfy the safety criteria in regard to the analyses to the extent to which they contain impurities.

The APVMA does not hold data to demonstrate that sources of paraquat dichloride technical concentrate approved prior to the revision of the standard listed in Table 4 (apart from approvals 44249 and 55966) meet the current standard. To demonstrate that these approvals satisfy the safety criteria, holders should provide recent Declarations of Composition and batch analyses demonstrating compliance with the revised APVMA standard (and the FAO specification) for paraquat dichloride.

Table 4: Current paraquat active constituent approvals

Approval number	Formulation	Holder
44249	Manufacturing concentrate	Syngenta Australia Pty Ltd
44387	Manufacturing concentrate	Nufarm Australia Limited
48272	Manufacturing concentrate	Syngenta Australia Pty Ltd
51041	Manufacturing concentrate	Ronic International Pty Ltd
54043	Manufacturing concentrate	Halley International Enterprise (Australia) Pty Ltd
54131	Manufacturing concentrate	Capital Commodities (Vic) Pty Ltd
55327	Manufacturing concentrate	ADAMA Australia Pty Ltd
55682	Manufacturing concentrate	Imtrade Australia Pty Ltd
55966	Manufacturing concentrate	Syngenta Australia Pty Ltd
56809	Manufacturing concentrate	Conquest Crop Protection Pty Ltd
58230	Manufacturing concentrate	Sinon Australia Pty Ltd
59171	Manufacturing concentrate	Agrogill Chemicals Pty Ltd
64565	Manufacturing concentrate	FMC Australasia Pty Ltd
64765	Manufacturing concentrate	Sharda Worldwide Exports Pvt Ltd
69493	Manufacturing concentrate	Grow Choice Pty Ltd
87171	Manufacturing concentrate	Agrogill Chemicals Pty Ltd
89426	Manufacturing concentrate	Hebei Shanli Chemical Company Limited
91420	Technical concentrate	Jiangsu Noon Crop Science CO., LTD

2.2 Formulated products

There are currently 119 registered agricultural chemical products containing paraquat as an active constituent. The 8 products registered since preparation of the APVMA's proposed regulatory decisions which were published on 30 July 2024 will not be dealt with in this document but will be addressed outside the reconsideration process.

Of these, 37 also contain diquat as a secondary active constituent (with 2 registered after preparation of the proposed decisions) while 2 contain amitrole in addition to paraquat. The products are listed in Table 4, grouped by product format (formulation type, paraquat content, and other actives). Due to the need for consideration of paraquat and diquat together in products containing both actives, these products have been designated as group 2 in this reconsideration (paraquat) and in the concurrent diquat reconsideration.

Table 5: Currently registered agricultural products containing paraquat

Registration number	Product name	Holder	Active constituents	Product group
Soluble concentrate products containing paraquat as paraquat dichloride				
46531	Gramoxone 250 Herbicide	Syngenta Australia Pty Ltd	Paraquat 250 g/L	1a
51958	Accensi Paraquat 250 Herbicide	Accensi Pty Ltd	Paraquat 250 g/L	1a
52141	Kendon Sprayquat 250 Herbicide	Kendon Chemicals & Mnfg Co Pty Ltd	Paraquat 250 g/L	1a
53381	Imtrade Paraquat 250 Herbicide	Imtrade Australia Pty Ltd	Paraquat 250 g/L	1a
53919	Nufarm Shirquat Herbicide	Nufarm Australia Limited	Paraquat 250 g/L	1a
54520	Halley Paraquat 250 Herbicide	Halley International Enterprise (Australia) Pty Ltd	Paraquat 250 g/L	1a
54522	Spraytop 250 SL Herbicide	ADAMA Australia Pty Limited	Paraquat 250 g/L	1a
56102	Kenso Agcare Para-Ken 250 Herbicide	Kenso Corporation (M) Sdn. Bhd.	Paraquat 250 g/L	1a
57817	Conquest Explode 250 Herbicide	Conquest Crop Protection Pty Ltd	Paraquat 250 g/L	1a
58841	Genfarm Paraquat 250 Herbicide	Nutrien Ag Solutions Limited	Paraquat 250 g/L	1a
58992	Sinmosa 250 Herbicide	Sinon Australia Pty Limited	Paraquat 250 g/L	1a
59419	Inferno Herbicide	Sipcam Pacific Australia Pty Ltd	Paraquat 250 g/L	1a
61254	Biotis Paraquat 250 Herbicide	Biotis Life Science Pty Ltd	Paraquat 250 g/L	1a
61869	Titan Paraquat 250 Herbicide	Titan Ag Pty Ltd	Paraquat 250 g/L	1a

Registration number	Product name	Holder	Active constituents	Product group
62096	Choice Paraquat 250 Herbicide	Grow Choice Pty Limited	Paraquat 250 g/L	1a
64281	Farmalinx Parquat 250 Herbicide	Farmalinx Pty Ltd	Paraquat 250 g/L	1a
64588	Smart Paraquat 250 Herbicide	Crop Smart Pty Ltd	Paraquat 250 g/L	1a
64651	Rc Paraquat 250 Herbicide	Ruralchem Pty Ltd	Paraquat 250 g/L	1a
64706	Fosterra Paraquat 250 Herbicide	Fosterra Pty Ltd	Paraquat 250 g/L	1a
64731	Agro-Essence Paraquat 250SL	Agro-Alliance (Australia) Pty Ltd	Paraquat 250 g/L	1a
65524	Proterra Paraquat 250 Herbicide	Proterra Pty Ltd	Paraquat 250 g/L	1a
65537	Sanonda Herbicide Paraquat 250sl	Sanonda (Australia) Pty Ltd	Paraquat 250 g/L	1a
65694	Rainbow Paraquat 250 Sl Herbicide	Shandong Rainbow International Co Ltd	Paraquat 250 g/L	1a
65713	Pacific Paraquat 250 Herbicide	Pacific Agriscience Pty Ltd	Paraquat 250 g/L	1a
66103	Apparent Paraquat 250 Herbicide	Titan Ag Pty Ltd	Paraquat 250 g/L	1a
66249	AW Putout 250 Herbicide	Agri West Pty Limited	Paraquat 250 g/L	1a
66531	ACP Paraquat 250 Herbicide	Australis Crop Protection Pty Ltd	Paraquat 250 g/L	1a
66548	Echem Paraquat 250 Herbicide	Echem (Aust) Pty Limited	Paraquat 250 g/L	1a
67163	Easyfarm Paraquat 250 SL Herbicide	Easyfarm Pty Ltd	Paraquat 250 g/L	1a
67307	AC Piston 250 Herbicide	Axichem Pty Ltd	Paraquat 250 g/L	1a
67437	Agroquat 250 Herbicide	Agrogill Chemicals Pty Ltd	Paraquat 250 g/L	1a
67888	Spalding Paraquat 250 Herbicide	DGL Environmental Pty Ltd	Paraquat 250 g/L	1a

Registration number	Product name	Holder	Active constituents	Product group
67977	Ezycrop Paraquat 250 SL Herbicide	Ezycrop Pty Ltd	Paraquat 250 g/L	1a
68196	Novaguard Paraquat 250 SL Herbicide	Novaguard Pty Ltd	Paraquat 250 g/L	1a
68477	Agmate Paraquat 250 SL Herbicide	Agcare Pty Ltd	Paraquat 250 g/L	1a
69274	Sabakem Paraquat 250SL Herbicide	Sabakem Pty Ltd	Paraquat 250 g/L	1a
69712	Paradox 250 Herbicide	Sinon Australia Pty Limited	Paraquat 250 g/L	1a
81797	Relyon Paraquat 250 Herbicide	Nutrien Ag Solutions Limited	Paraquat 250 g/L	1a
83115	Kelpie Par-Q 250 Herbicide	Sinochem International Australia Pty Ltd	Paraquat 250 g/L	1a
84794	Agmerch Paraquat 250 SL Herbicide	Agmerch Pty Ltd	Paraquat 250 g/L	1a
85420	Hemani Paraquat 250 SL Herbicide	Hemani Australia Pty Ltd	Paraquat 250 g/L	1a
87370	Kelpie P-Quat 250 SL Herbicide	Sinochem International Australia Pty Ltd	Paraquat 250 g/L	1a
88941	Genfarm Paraquat 250 SL Herbicide	Nutrien Ag Solutions Limited	Paraquat 250 g/L	1a
89076	F.S.A. Paraquat 250 Herbicide	Four Seasons Agribusiness Pty Ltd	Paraquat 250 g/L	1a
89808	Genfarm Para 250 SL Herbicide	Nutrien Ag Solutions Limited	Paraquat 250 g/L	1a
90155	Cropsure Parashot 250 Herbicide	Cropsure Pty Ltd	Paraquat 250 g/L	1a
91098	Sanonda Paraquat 250 Herbicide	Sanonda (Australia) Pty Ltd	Paraquat 250 g/L	1a
91833	JN PARAQUAT 250 HERBICIDE	JIANGSU NOON CROP SCIENCE CO., LTD	Paraquat 250 g/L	1a
92586	Weed Force Dagger 250 Knockdown Herbicide	WEED FORCE PTY LTD	Paraquat 250 g/L	1a

Registration number	Product name	Holder	Active constituents	Product group
92841	Submarino Paraquat 250 SL Herbicide	SUBMARINO PTY LTD	Paraquat 250 g/L	1a
93958	Swan Paraquat 250 Herbicide	SWAN CHEMICAL HOLDINGS PTY LTD	Paraquat 250 g/L	1a
69502	Cruze 300 Herbicide	DGL Environmental Pty Ltd	Paraquat 300 g/L	1b
70143	Farmalinx Powerquat 300 SL Herbicide	Farmalinx Pty Ltd	Paraquat 300 g/L	1b
83185	Accensi Paraquat 300 Herbicide	Accensi Pty Ltd	Paraquat 300 g/L	1b
85110	Kelpie P-Quat 300 SL Herbicide	Sinochem International Australia Pty Ltd	Paraquat 300 g/L	1b
85169	Conquest Explode 300 Plus Herbicide	Conquest Crop Protection Pty Ltd	Paraquat 300 g/L	1b
87191	4Farmers Paraquat 300 Herbicide	4 Farmers Australia Pty Ltd	Paraquat 300 g/L	1b
89981	Smart Paraquat 300 Herbicide	Crop Smart Pty Ltd	Paraquat 300 g/L	1b
90742	Agro-Essence Paraquat 300 Herbicide	Agro-Alliance (Australia) Pty Ltd	Paraquat 300 g/L	1b
87665	Spraytop 330 Herbicide	ADAMA Australia Pty Limited	Paraquat 330 g/L	1c
64430	Kenso Agcare Para-Ken 334 Herbicide	Kenso Corporation (M) Sdn. Bhd.	Paraquat 334 g/L	1d
83010	Paraquick Force 350 Herbicide	Nutrien Ag Solutions Limited	Paraquat 350 g/L	1e
68577	Gramoxone 360 Pro Herbicide	Syngenta Australia Pty Ltd	Paraquat 360 g/L	1f
83835	Rainquat Full Herbicide	Shandong Rainbow International Co Ltd	Paraquat 360 g/L	1f
86364	Genfarm Paraquat 360 Herbicide	Nutrien Ag Solutions Limited	Paraquat 360 g/L	1f
86801	Ozcrop Paraquat 360 SL Herbicide	Oz Crop Pty Ltd	Paraquat 360 g/L	1f

Registration number	Product name	Holder	Active constituents	Product group
87228	Relyon Paraquat 360 Herbicide	Nutrien Ag Solutions Limited	Paraquat 360 g/L	1f
87259	Conquest Explode 360 Herbicide	Conquest Crop Protection Pty Ltd	Paraquat 360 g/L	1f
87271	ACP Paraquat 360 Herbicide	Australis Crop Protection Pty Ltd	Paraquat 360 g/L	1f
87424	Titan Paraquat 360 Herbicide	Titan Ag Pty Ltd	Paraquat 360 g/L	1f
91705	CropSure Parashot Plus 360 Herbicide	Cropsure Pty Ltd	Paraquat 360 g/L	1f
93182	Sabakem Paraquat 360SL Herbicide	SABAKEM PTY LTD	Paraquat 360 g/L	1f
93444	eChem Paraquat 360 Herbicide	ECHEM (AUST) PTY LIMITED	Paraquat 360 g/L	1f
94216	F.S.A. Paraquat 360 Herbicide	FOUR SEASONS AGRIBUSINESS PTY LTD	Paraquat 360 g/L	1f
Soluble concentrate (SL) formulation containing paraquat as paraquat dichloride and diquat as diquat dibromide				
46516	Spray.Seed 250 Herbicide	Syngenta Australia Pty Ltd	Diquat 115g/L paraquat 135g/L	2
58336	Halley Premier 250 Herbicide	Halley International Enterprise (Australia) Pty Ltd	Diquat 115g/L paraquat 135g/L	2
58412	Imtrade Spraykill 250 Herbicide	Imtrade Australia Pty Ltd	Diquat 115g/L paraquat 135g/L	2
58470	Conquest Scorcher 250 Herbicide	Conquest Crop Protection Pty Ltd	Diquat 115g/L paraquat 135g/L	2
58733	4Farmers Brown Out 250 Herbicide	4 Farmers Australia Pty Ltd	Diquat 115g/L paraquat 135g/L	2
59098	Spray-Plant 250 Herbicide	Sipcam Pacific Australia Pty Ltd	Diquat 115g/L paraquat 135g/L	2
59333	Kenso Agcare Speedy 250 Herbicide	Kenso Corporation (M) Sdn. Bhd.	Diquat 115g/L paraquat 135g/L	2
59878	Genfarm Di-Par 250 Herbicide	Nutrien Ag Solutions Limited	Diquat 115g/L paraquat 135g/L	2
60287	Combik 250 Herbicide	Sinon Australia Pty Limited	Diquat 115g/L paraquat 135g/L	2

Registration number	Product name	Holder	Active constituents	Product group
61460	Alarm Herbicide	Sipcam Pacific Australia Pty Ltd	Diquat 115g/L paraquat 135g/L	2
61860	Titan Eos Herbicide	Titan Ag Pty Ltd	Diquat 115g/L paraquat 135g/L	2
62495	Sanonda Paraquat/Diquat Herbicide	Sanonda (Australia) Pty Ltd	Diquat 115g/L paraquat 135g/L	2
62631	Accensi Paraquat/Diquat 250 Herbicide	Accensi Pty Ltd	Diquat 115g/L paraquat 135g/L	2
63565	Ozcrop Blowout Herbicide	Oz Crop Pty Ltd	Diquat 115g/L paraquat 135g/L	2
64325	Farmalinx Paradat Herbicide	Farmalinx Pty Ltd	Diquat 115g/L paraquat 135g/L	2
64704	Fosterra Paraquat / Diquat Herbicide	Fosterra Pty Ltd	Diquat 115g/L paraquat 135g/L	2
64802	Kwicknock 250 Herbicide	Grow Choice Pty Limited	Diquat 115g/L paraquat 135g/L	2
65295	Rainbow Diqu-Para 250 Herbicide	Shandong Rainbow International Co Ltd	Diquat 115g/L paraquat 135g/L	2
65708	Pacific Diquat/Paraquat 250 Herbicide	Pacific Agriscience Pty Ltd	Diquat 115g/L paraquat 135g/L	2
66327	AW Dismantle Herbicide	Agri West Pty Limited	Diquat 115g/L paraquat 135g/L	2
66788	Agro-Essence Paraquat+Diquat 250 Herbicide	Agro-Alliance (Australia) Pty Ltd	Diquat 115g/L paraquat 135g/L	2
67399	Easyfarm Paraquat-Diquat 250 Herbicide	Easyfarm Pty Ltd	Diquat 115g/L paraquat 135g/L	2
67627	Apparent Weedy Seedy 250 Herbicide	Titan Ag Pty Ltd	Diquat 115g/L paraquat 135g/L	2
67707	Smart Combination 250 Herbicide	Crop Smart Pty Ltd	Diquat 115g/L paraquat 135g/L	2
67891	Spalding Exocet 250 Herbicide	DGL Environmental Pty Ltd	Diquat 115g/L paraquat 135g/L	2
68075	Ezycrop Paraquat-Diquat 250 Herbicide	Ezycrop Pty Ltd	Diquat 115g/L paraquat 135g/L	2

Registration number	Product name	Holder	Active constituents	Product group
68202	Novaguard Paraquat-Diquat 250 Herbicide	Novaguard Pty Ltd	Diquat 115g/L paraquat 135g/L	2
68280	Agro Burner 250 Herbicide	Agrogill Chemicals Pty Ltd	Diquat 115g/L paraquat 135g/L	2
68479	Agmate Paraquat & Diquat 250 SL Herbicide	Agcare Pty Ltd	Diquat 115g/L paraquat 135g/L	2
81790	Relyon Di-Par 250 SC Herbicide	Nutrien Ag Solutions Limited	Diquat 115g/L paraquat 135g/L	2
83923	Accensi Paraquat / Diquat Prime 250 Herbicide	Accensi Pty Ltd	Diquat 115g/L paraquat 135g/L	2
85112	Raystar Paraquat Diquat SL Herbicide	Raystar Cropprotection Pty Ltd	Diquat 115g/L paraquat 135g/L	2
89832	Genfarm Di-Par 250 SC Herbicide	Nutrien Ag Solutions Limited	Diquat 115g/L paraquat 135g/L	2
90172	Cropsure Squadron 250 Herbicide	Cropsure Pty Ltd	Diquat 115g/L paraquat 135g/L	2
91135	QA Paraquat/Diquat 250 SL Herbicide (previously Agmerch Paraquat 135 & Diquat 115 Herbicide)	Agmerch Pty Ltd	Diquat 115g/L paraquat 135g/L	2
Soluble concentrate products containing paraquat and amitrole				
67344	Imtrade Para-Trooper Herbicide	Imtrade Australia Pty Ltd	250 g/L paraquat, 10 g/L amitrole	3a
89484	Imtrade Guerrilla Herbicide	Imtrade Australia Pty Ltd	300 g/L paraquat, 12 g/L amitrole	3b

2.3 Statutory considerations under the safety criteria – formulated products

Under section 5A of the Agvet Code, when determining whether a chemical product satisfies the safety criteria, the APVMA must (among other matters) have regard to:

- how the product is formulated
- the composition and form of the constituents of the product
- any relevant particulars entered into the register for the product.

The APVMA may have regard to:

- the stability of the product
- specifications for containers for the product.

The APVMA has previously assessed the formulation details, constituent specifications, formulation type, manufacturing process (how the product is formulated), stability and containers of each proposed product prior to registration. Noting that these assessments include confidential commercial information, further details are not discussed in this report. In the case of paraquat products, this included the requirement under the Therapeutic Goods (Poisons Standard—February 2026) Instrument 2026 (Poisons Standard) and preceding instruments for products containing paraquat to contain a blue or green dye and sufficient stenching agent to give the product an offensive smell. Based on the information provided and assessed at the time of registration, it is recommended that the APVMA remain satisfied with respect to the chemistry related aspects of the safety criteria for products containing paraquat dichloride as the active constituent in relation to how the product is formulated, the composition and form of the constituents of the products and product stability. Additional excipients and manufacturing impurities from the active constituent up to the levels declared in the declarations of composition are considered acceptable and do not present any additional toxicological concern.

The APVMA was satisfied at the time of registration that containers for products met the relevant safety criteria.

All currently registered paraquat products are soluble concentrates. The formulation type for currently registered products should be recorded as soluble concentrate (SL) and the register corrected if required.

2.4 Recommendations

The recommendations of the chemistry assessment of paraquat are that the APVMA:

- Be satisfied that the paraquat dichloride active constituents (manufacturing concentrates) with the approval numbers 69493, 87171, 89426 and 91420 continue to meet the safety criteria from a Chemistry and Manufacture perspective.
- Not be satisfied that the active constituents with the approval numbers 44249, 55966 meet the safety criteria as the Declaration of Composition provided for those active constituents do not list all required impurities and components for paraquat dichloride technical concentrates listed in the Agricultural Active Constituent Standards 2022 or FAO Specification for paraquat dichloride.
- Not be satisfied that the remaining active constituent approvals listed in Table 4 meet the safety criteria as the holders have not demonstrated that the active constituents conform to the Agricultural Active Constituents Standard 2022 or FAO Specification for paraquat dichloride.
- Could be satisfied that all paraquat dichloride active constituent approvals listed in Table 4 meet the safety criteria if the holders of those approvals provide an updated Declaration of Composition (44249, 55966), or an updated Declaration of Composition and the results of 5 batch analyses (44387, 47747,48272, 51041, 51678, 54043, 54131, 55327, 55682, 56809, 58230, 59171, 64565), as needed, conforming to the Agricultural Active Constituents Standard 2022 and FAO Specification for paraquat dichloride, to the APVMA.
- Be satisfied that continued registration of agricultural chemical products containing paraquat dichloride, listed in Table 5, would meet the safety criteria under section 5A of the Agvet Code from a Chemistry and

Manufacture perspective. Minor corrections should be made to the recorded formulation types of some products, to ensure consistent use of terminology.

3 Toxicology

A large toxicology database is available for paraquat and was considered to be of sufficient breadth and quality for human health risk assessment purposes. The following toxicology section is a summary of the conclusions of the mammalian toxicology and metabolism / toxicokinetics of paraquat assessments completed by the APVMA and published in 2016 as the Paraquat toxicology report available at https://apvma.gov.au/node/12666.

Since the publication of this report, the United States Environmental Protection Agency (US EPA) has published detailed and comprehensive reviews of the toxicology and epidemiology of paraquat used as an herbicide (2019 a,b,c). In addition, the APVMA has completed a review of submissions received in response to the public consultation on the Proposed Regulatory Decision on paraquat (consultation period 30 July 2024 to 29 October 2024). The new studies that were reviewed in these reports build upon the toxicological database for paraquat but do not change the overall conclusions of the paraquat toxicology report (2016) and do not introduce any new toxicological endpoints that would alter the existing health-based guidance values and exposure assessments of paraquat.

3.1 Evaluation of toxicology

3.1.1 Biochemical aspects

Paraquat is poorly absorbed following oral dosing in the rat, with only 10 to 18% of an oral dose absorbed. Following absorption, paraquat is widely distributed, with highest initial concentrations in the kidneys and lungs, however, is not extensively metabolised. In rats, more than half of the administered dose is excreted in the faeces (60 – 70%), with smaller amounts (10 – 20%) in the urine. While almost half of the administered dose was excreted within 48 hours of dosing, measurable amounts were detected for up to 21 days after dosing. In rats, the dose, frequency of dosing or sex of study animals did not result in major differences in absorption, distribution or excretion. The active uptake system indicates a potential for accumulation in the rat or rabbit lung.

In vitro studies conducted on the manufacturing concentrate revealed that absorption across rabbit skin was approximately 1% over 10 h, and 2.5% over 55 h for human skin. In addition, human skin was found to be at least 40 times less permeable than animal skin tested in vitro (including rat, mouse, rabbit and guinea-pig). A single *in vivo* study conducted in male human volunteers determined that approximately 0.3% of an applied dose was absorbed over 120 h.

Percutaneous absorption of paraquat in rats ranged from 0.003-16.54% of the applied dose and was approximately proportional to the amount applied. Human skin or isolated epidermis showed lower levels of absorption (0.0001-1.43%) and was also proportional to the amount of paraquat applied. In most studies, absorption rates were higher after 10-12 hours of administration, possibly due to tissue degradation. Although the composition of these formulations was largely unknown, a number of studies indicated that the presence of diquat in the formulation had no effect on percutaneous paraquat absorption.

3.1.2 Major toxicological mode(s) of action and key events

The mechanism of mammalian toxicity of paraquat is via the generation of highly reactive free radicals and consequent peroxidation of membrane lipids, sulfhydryl groups, proteins and DNA, leading to membrane damage and cell death.

3.1.3 Acute toxicity in animals

The acute oral toxicity of paraquat is moderate in rodents (LD50 from 100 – 249 mg/kg bw) (Kimbrough & Gaines, 1970; Duerden, 1994b), and high in guinea pigs, rabbits, dogs and monkeys (LD50=22, 40-50 and 50 mg/kg bw, respectively) (Murray & Gibson, 1972; Farnworth et al, 1993). A range of clinical signs have been observed in laboratory animals following acute oral exposures including hypoactivity, dehydration, hypothermia, irregular breathing, reduced faecal output, piloerection, staining around the mouth and upward curvature of the spine.

In rats, the acute dermal toxicity of paraquat is low (LD50 > 1448 mg/kg bw) (Duerden, 1994c) and the acute inhalational toxicity extremely high (LC50 = 0.5 mg/m3, whole body exposure, 4-h) (Hathaway, 1966). The most concentrated aqueous solution of paraquat (33% paraquat cation, w/w) was a severe eye irritant in rabbits (Bugg & Duerden, 1994). A 28.6% (w/w) paraquat solution was a moderate to severe skin irritant in rabbits when tested undiluted or up to 1:25 (v/v) dilution, but a slight irritant from dilutions of 1:50 (Bullock, 1983). Paraquat was not a skin sensitiser in guinea pigs (Thompson et al, 1985).

3.1.4 Acute toxicity in humans

In humans, following oral exposure to formulated products, vomiting, abdominal pain, nausea, diarrhoea, ulceration of the oral and/or pharyngeal mucosa and gastrointestinal tract, irritability, dyspnoea, and tachycardia have been observed. There have been relatively few cases of fatality due to dermal paraquat exposure, although it appears that toxicologically significant absorption can occur via damaged skin or sensitive skin areas such as the scrotum. Five fatalities were reported in Papua New Guinea as a result of occupational accidents or off-label use (to treat head lice or scabies). Exposure in these cases was via several routes including the skin of the scrotum, back, thighs, scalp, head, face or nose, although in at least one case, oral ingestion was strongly indicated due to ulceration in the mouth and throat. Similar case reports have involved exposure of the scrotum resulting in pulmonary fibrosis, renal and respiratory failure, with eventual recovery of the patients. Other human poisoning cases reported systemic toxicity and death following absorption through scratches and cutaneous lesions (including skin blisters) on the arms and legs.

Most occupational studies have shown that clinical signs or death due to repeated dermal exposure to paraquat are rare. In an occupational setting, the major manifestation of dermal paraquat toxicity appears to be localised skin reactions, rashes, burns and dermatitis at the exposure site/s.

3.1.5 Repeat dose toxicity

In numerous repeat-dose studies, the toxicological effects of paraquat were dose-related and appeared to be independent of sex, dosing route or duration. Dogs were the most sensitive test species followed by rodents and rabbits. Pulmonary toxicity was the predominant feature of repeated paraquat exposure, while renal damage can also occur. Gastrointestinal effects, including irritation, mucosal erosion or ulceration were observed in some rat and rabbit studies following oral dosing.

At high enough oral doses (~20 mg/kg bw/d in rodents, ~1 mg/kg bw/d in dogs) decreased body weight gain, clinical signs (ataxia, laboured or rapid breathing, general malaise, lethargy, piloerection, weight loss) and mortalities eventuated.

3.1.5.1 Pulmonary toxicity

Localised tissue damage was apparent following inhalational or dermal exposure. Short-term inhalational studies conducted in rats revealed damage to the airways and throat, manifesting as metaplasia and/or hyperplasia of the epiglottis and arytenoid projections, and ulceration/necrosis and acute inflammatory cell infiltration in the larynx. Lung damage including loss of cilia and clara cells and the presence of mucous, debris or inflammatory cell infiltrates were also detected.

The types of gross and histopathological lung abnormalities observed in laboratory animals included alveolitis, alveolar wall thickening, congestion, collapse, fibrosis, haemorrhage, macrophage or lymphocyte infiltration, necrosis, oedema, the presence of inflammatory or congestive lesions of various size (a few mm to involvement of most of the lung) and colour (dark red, brown grey or black), and increased lung weight.

3.1.5.2 Renal toxicity

Paraquat-induced renal toxicity was observed, including by the occurrence of congestion, tubular degeneration, hydronephrosis and the urinary shedding of renal cells. Renal function was adversely affected, as shown by the elevation in plasma urea and creatinine, and urinary glucose, protein and albumin. Several studies also showed elevations in haematocrit (Hct) and erythrocyte counts (RBC) which were probably the result of decreased plasma volume due to dehydration.

3.1.5.3 Ocular toxicity

Ocular abnormalities, including retinal engorgement, were detected in dogs at doses from 0.175 – 3 mg/kg bw/day, but were not seen at lower doses (up to 1.25 mg/kg bw/day). In rats, opacity and cataracts were observed at and above 3.75 mg/kg bw/day, and lenticular degeneration at and above 1.25 mg/kg bw/day. These studies suggest that relatively high oral doses of paraquat can lead to ocular abnormalities in rats and dogs, however the mechanism of their formation has not been further elucidated.

3.1.5.4 Genotoxicity

There was limited activity in mutagenicity studies. While there were occasional findings of clastogenicity, the weight of evidence indicates that paraquat is non-mutagenic.

3.1.5.5 Carcinogenicity

Long-term feeding studies at a range of doses in mice and rats revealed no evidence that paraquat was carcinogenic.

3.1.5.6 Reproduction studies

There was no evidence that paraquat caused reproductive toxicity in rats following dietary administration at up to 14.5 mg/kg bw/day, doses which produced systemic toxicity in parental animals.

Signs of toxicity included lung lesions, decreased food consumption and body weight. Offspring showed decreased body weight in addition to hydrourethrosis or perivascular inflammatory cell infiltration in the lungs.

Dermal treatment of male rats at doses up to 30 mg/kg bw/day showed weak cytotoxic effects on epididymal sperm and late spermatids. No dose-response was observed, and the significance of this effect are questionable in the absence of demonstrated effects on male fertility in reproduction studies.

3.1.5.7 Developmental studies

Studies in mice, rats and rabbits did not show evidence that paraquat had potential to adversely affect development. Maternotoxic doses produced minor effects such as delayed or incomplete ossifications, reduced foetal weights and viability, and, in one rabbit study, post-implantation losses. No observed adverse effect levels were 1 mg/kg bw/day for maternal toxicity and foetal effects in rats and rabbits, while in mice the foetal NOAEL was slightly higher.

In humans, following deliberate ingestion, paraquat crossed the placenta, and was found in higher levels in foetal tissue than in maternal plasma. At maternally fatal doses, all foetuses died, while in 2 surviving women the pregnancy proceeded normally with no evidence of teratogenicity.

3.1.6 Special studies

3.1.6.1 Neurotoxicity

The APVMA completed an assessment of the potential for neurotoxicity mediated by paraquat and published these findings in detail in the 2016 report Paraquat toxicology report – supplement II neurotoxicology. Since this report, the United States Environmental Protection Agency (US EPA) has published detailed and comprehensive reviews of the toxicology and epidemiology of paraquat used as a herbicide (US EPA, 2019a,b) and the APVMA has completed a review of submissions received in response to the public consultation on the Proposed Regulatory Decision on paraquat, which included a number of submissions relevant to the investigation of paraquat and Parkinson's Disease. A summary of the key findings of these reports is provided below.

Animal studies submitted as part of the public consultation that were published after the completion of the APVMA paraquat toxicology report (2016), or that were identified as part of a contemporary literature search completed in 2025 (Anderson et al., 2021; Dwyer et al, 2021; Milanese et al., 2018; Sun et al., 2023; Smeyne et al., 2016; Torres-Rojas et al., 2022; Wang et al., 2016) confirm and reinforce the previous conclusion that available animal data does not provide convincing evidence that paraquat presents a substantive risk of increasing Parkinson's like disease in humans from likely routes and magnitude of exposure arising from agricultural use. The previous conclusion of the APVMA paraquat technical report that paraquat in animal studies "does not induce neurotoxicity via the oral, dermal or intranasal exposure routes" remains appropriate. The 2019 US EPA review of the literature on the relationship between paraquat and Parkinson's disease concluded that "Overall, the limited, mixed findings in the animal literature were considered weak evidence of a Parkinson's disease-like response to paraquat exposure." No data has been identified from public submissions or the available literature that would alter the validity of these conclusions.

Epidemiology studies submitted as part of the public consultation that were published after the completion of the APVMA paraquat toxicology report (2016), or that were identified as part of a literature search included studies that examined a UK workforce who manufactured paraquat between 1961 and 1995 (Tomenson & Campbell, 2021), dispensing data for Parkinson's disease medications across 79 Local Government Areas in Victoria (Ayton et al., 2019), the Parkinsons Environment and Genes (PEG) study (Paul et al., 2024; Sanders, et al., 2017) and the very large US Agricultural Health Survey (AHS) study cohort (Shrestha et al., 2019; Shrestha et al., 2020; Yuan et al., 2022). These studies support and strengthen the overall conclusion that cause and effect for paraquat exposure and Parkinson's disease risk have not been convincingly demonstrated, a conclusion supported by the US EPA reviews (2019 a,b,c).

The overall conclusions of this report, the 2016 APVMA review of paraquat neurotoxicology and the extensive US EPA (2019 a,b,c) reviews is that the evidence available to date does not convincingly demonstrate a direct causal association between exposure to paraquat occupationally and/or through residential exposure to pesticides used on nearby land, and an increased risk of developing Parkinson's disease. As noted by the US EPA (2019 a,c) although Parkinson's disease-like effects are seen in some animals administered paraquat via injection, given the substantial differences in toxicokinetic behaviour from anticipated routes of exposure and parenteral dosing in animals, toxicity data reported for injection studies is of limited use to assessing human risk from pesticidal uses of paraquat.

The APVMA will continue to monitor for additional data and regulatory outcomes on paraquat. Any new data that becomes available to the APVMA will be reviewed and addressed as appropriate.

3.1.6.2 Human studies

3.1.6.2.1 Occupational exposure

Localised skin reactions and damage resulting for unintentional exposure have been reported in overseas workers, typically associated with poor work practices, including faulty equipment and/or the lack of suitable protective equipment.

Epidemiology studies have investigated a possible link between paraquat and an increased risk of developing Parkinson's disease. Contemporary studies do not indicate a robust association between adverse health effects and exposure to pesticides. A retrospective worker cohort study did not indicate any evidence of an increased risk of Parkinson's disease in paraquat production facilities, with moderate to high levels of exposure to paraquat (Tomenson & Campbell (2021)). It is concluded that the available epidemiology data is insufficient to conclude any association between paraquat exposure and neurotoxicity (including Parkinson's disease) in the occupational environment.

3.1.6.2.2 Poisoning incidents

Direct ingestion of commercial paraquat products has resulted in a large number of human poisonings in many parts of the world. Limited data is available in Australia on paraquat poisonings, as these are generally classified under more generic categories (such as herbicide or weed killer). There are currently no effective antidotes or treatment regimes, and treatment is supportive, including gastric lavage, haemodialysis or haemoperfusion. A reliable indicator of the likelihood of survival following poisoning appears to be the dose, as well as how quickly treatment is initiated after exposure.

3.2 Health-based guidance values

The points of departure established in the Human Health Risk Assessment (APVMA 2016 (a)) are detailed in Table 6.

Table 6: Points of Departure for Human Health Risk Assessment

Study type		Key effect	Point of departure	Reference
Repeat dose exposure				
Short term oral exposure	28 day oral (dietary) repeat dose; mouse)	Histopathological lung abnormalities (alveolar wall thickening, congestion and oedema	NOEL not established LOEL 15 mg/kg bw/day	Sotheran *et al* (1979)
	28 day oral (dietary) repeat dose; rat)	Decrease body weight gain, decreased food consumption, histopathological lung abnormalities (alveolar wall thickening, congestion and oedema	NOEL – not established LOEL – 15 mg/kg bw/day	Hodge *et al* (1980)
Intermediate term oral exposure	13 week dietary repeat dose, mouse	Macroscopic and histopathological lung abnormalities,	NOEL – 11.5 mg/kg bw/day (males)	Maita & Saito (1980)
	13 week dietary repeat dose, rat (adult)	Lung abnormalities (alveolar epithelial hypertrophy in males) and splenic abnormalities (in females)	NOEL – 6.6 mg/kg bw/day (males)	Maita *et al* (1980)
	13 week dietary repeat dose, dog	Macroscopic lung lesions and histopathological signs of alveolitis	NOEL – 0.5 mg/kg bw/day	Sheppard (1981(b))
	1 year dietary repeat dose, dog	Pulmonary lesions associated with chronic pneumonitis	NOEL – 0.45 mg/kg bw/day	Kalinowski *et al* (1983(a, b))

Study type		Key effect	Point of departure	Reference
Long term oral exposure	2 year oral (dietary repeat dose; rat (adult)	Ocular lesions	NOEL – not established LOEL – 1.25 mg/kg bw/day	Woolsgrove, 1983; Ashby & Finn, 1983; Ishmael & Godley, 1983; Brown & Whitney, 1984; Woolsgrove & Ashby, 1985; Life Sci Res Inst, 1984; Ishmael, 1987
Reproduction and development				
Reproduction	Three-generation reproduction study; rat	Parents: increase in incidence and severity of focal alveolar histiocytosis Offspring: perivascular inflammatory cell infiltration	Parental: NOAEL 1.25 mg/kg bw/day Offspring: NOAEL 7.5 mg/kg bw/day	Lindsay *et al* (1982 (a,b))
Development				
Maternal toxicity	Developmental toxicity study; rat, rabbit	Mortality, reduced body weight gain	NOEL – 1 mg/kg bw/day	Hodge *et al,* 1978
Foetal development	Developmental toxicity study; rabbit	Delayed ossification with increased incidence of developmental variations	NOEL – 1 mg/kg bw/day	Tinston 1991(a,b,c)

Based on the evaluation of the available toxicological database the current APVMA acceptable daily intake (ADI; shown in Table 7) and acute reference dose (ARfD; shown in Table 8) will be retained, however changes have been made to the text used to define the ARfD in the Human Health Risk Assessment (APVMA 2016 (a)), these are included in Table 8.

Table 7: Acceptable daily intake for paraquat

Chemical	ADI mg/kg bw/day	NOAEL	Date	Study	Comments
Paraquat	0.004	0.45	27 June 2003	1-year dietary dog study; a NOAEL of 0.45 mg/kg bw/d was based on pulmonary lesions at the next higher dose.	Acceptable margin of exposure ≥ 100.

Table 8: Acute reference dose for paraquat

Chemical	ARfD mg/kg bw/day	NOAEL	Date	Study	Comments
Paraquat	0.004	0.45	27 June 2003	One-year chronic feeding dog study; a NOAEL of 0.45 mg/kg bw/d was based on the likelihood that the observed pulmonary lesions would also occur after an acute exposure at the next higher dose.	

3.3 Poisons scheduling

Paraquat is currently in included in Schedule 7 of the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP). In recognition of the significant toxicity of paraquat, in addition to the signal heading "DANGEROUS POISON", aqueous solutions of paraquat must also bear the cautionary statements:

CAN KILL IF SWALLOWED
DO NOT PUT IN DRINK BOTTLES
KEEP LOCKED UP

These statements must be printed on separate lines immediately below the cautionary statement "KEEP OUT OF REACH OF CHILDREN". The SUSMP also requires that liquid preparations of paraquat must be coloured blue or green and must contain sufficient stenching agent to produce an offensive smell.

All registered paraquat products comply with these requirements and no changes to the current poisons scheduling are required.

3.4 Recommendations

The toxicological component of the Review Technical Report considered the hazards identified in acute, short-term, chronic, reproduction and developmental toxicity studies, genotoxicity, carcinogenicity and neurotoxicity studies of paraquat.

The paraquat toxicology component of the Review Technical Report concluded that:

- the acceptable daily intake (ADI) for paraquat should remain at 0.004 mg per kilogram body weight per day based on a no observed adverse effect level (NOAEL) of 0.45 mg/kg bw/day in a one-year dog dietary study, based on pulmonary lesions at the next higher dose. The ADI incorporates a 100-fold uncertainty factor to account for inter- and intra-species variation in sensitivity

- the acute reference dose (ARfD) for paraquat should remain at 0.004 mg of paraquat per kg body weight based on a no observed adverse effect level (NOAEL) of 0.45 mg per kilogram body weight in a dog dietary study, considering that pulmonary lesions would also occur after an acute exposure at the next higher dose. The ARfD incorporates a 100-fold uncertainty factor to account for inter- and intra-species variation in sensitivity
- that the scheduling for paraquat in the Standard for the Uniform Scheduling of Medicines and Poisons remains unchanged.

Provided conditions of registration and label instructions are followed, the active constituents and registration of products containing paraquat:

- would not be an undue health hazard to the safety of people exposed to it during its handling or people using anything containing its residues
- would not be likely to have an effect that is harmful to human beings.

4 Worker health and safety

4.1 Worker exposure assessment

This exposure assessment and risk characterisation includes professional workers who mix, load and apply paraquat and combination products and professional workers who re-enter treated areas.

For exposure during mixing, loading and application, the current assessment has utilised the US EPA Office of Pesticide Programs Occupational Handler Exposure Unit Surrogate Exposure Reference Table (US EPA, 2021(a)). For exposure associated with re-entry into pesticide treated area, the current assessment has utilised the US EPA Occupational Pesticide Post-Application Exposure Data and Calculator (US EPA, 2021(b)).

The following assumptions have been used in the exposure modelling (see Table 9). Application by aircraft has not been assessed, as this use is not supported on currently approved labels.

Table 9: Assumptions used in modelling exposure for professional use of paraquat products and paraquat plus diquat products

Parameters	Values
Point of departure for risk assessment (paraquat)	0.045 mg/kg bw/day (based on NOAEL of 0.45 mg/kg bw/day and a 10% oral availability
Point of departure for risk assessment (diquat)	0.282 mg/kg bw/day (based on NOAEL of 4.7 mg/kg bw/day and 6% oral availability)
Acceptable margin of exposure (MOE)	100[2]
Body weight (adult)	80 kg
Body weight (child)	1 to 2 y: 11 kg 2 to 3 y: 15 kg
Dermal absorption factor (paraquat)	0.3%
Dermal absorption factor (diquat)	3.3%
Inhalation absorption factor (paraquat and diquat)	100%
Groundboom field application (most crops)	50 to 500 ha/day
Groundboom field application (cotton)	400 ha/day
Groundboom field application (broadacre uses)	500 ha/day
Backpack application (mixer, loader, applicator)	150 L dilute product/day

[2] As a NOAEL from an animal study was used to estimate risks, an acceptable MOE ≥ 100 was considered acceptable. This value is based on a 10-fold uncertainty factor (UF) for intra-species and 10-fold UF for inter-species differences.

Parameters	Values
Manually pressurised hand wand application	150 L dilute product/day
Mechanically pressurised hand wand application	Spot treatment foliar = 1,000 L dilute product/day Broadcast foliar = 4,000 L dilute product/day

The exposure assessments and risk characterisations for professional use of paraquat also rely upon a further series of reasonable assumptions, notably that professional users:

- are trained in accurate mixing, loading and application methods
- are trained in, and are competent and experienced users of, personal protective equipment and relevant application techniques and equipment
- have a high level of compliance with label directions, including label-specified application rates and the use of personal protective equipment specified on product labels
- wear long-sleeved shirt, long pants, shoes and socks or an equivalent single layer of clothing when using paraquat, in addition to any personal protective equipment specified on product labels.

4.1.1 Ground-based application

The outcomes for the exposure risk assessments for the professional use of paraquat in agricultural situations using ground-based application equipment are set out in Table 10 and Table 11. Modelling for ground-based application assumed that all steps in the use of paraquat products are performed by an individual worker (i.e. an individual worker mixes, loads and applies the herbicide) and that there was only one type of use or activity performed per operator per day. Modelling for re-entry activities (8-hour days) assessed worker exposure via dermal exposure, as inhalation exposure under these circumstances is regarded as negligible. It is noted that the calculated re-entry intervals are not required when crops are treated at the bare soil or pre-emergent stage.

Instead of modelling exposure for a pre-determined work rate (scale of use), the APVMA used a reverse exposure modelling approach to determine the maximum active handling rate that can be used for per day for an individual worker. Dermal and inhalation unit exposure values were obtained from the US EPA Office of Pesticide Programs Occupational Handler Exposure Unit Surrogate Exposure Reference Table (US EPA, 2021(a)). The APVMA then assessed whether the maximum active handling rate was practical based on the expected scale of use (as indicated in Table 10 and Table 11). As the maximum concentration of paraquat applied per hectare is limited by the findings of the environment risk assessment (see section 6), it is implausible for the maximum safe handling rates to be exceeded in most circumstances, when the product is applied according to the directions for use. Accordingly daily work-rate limitations are not required to mitigate risks of exposure to workers, except for mechanically pressurised hand wand application.

Table 10: Risk assessment outcomes for liquid paraquat products

Activity	Scale of use assessed	Minimum acceptable Personal Protective Equipment (PPE)[3]	Use acceptable (Yes/No/Restricted)
Ground boom application mix, load, and apply (a single operator mixes, loads and applies)	Small scale agriculture (up to 6 ha/day)	Open cab Single layer Gloves PF10 respirator Face shield or goggles when mixing and loading	Restricted[3] Maximum acceptable handling rate of 75.3 kg paraquat per individual worker per day
	Broad scale agriculture (up to 500 ha/day)	Enclosed cab application Enclosed mixing and loading (single layer of clothing, gloves, PF10 respirator, face shield or goggles when connecting, disconnecting or cleaning components of the mixing and loading system)	Restricted[3] Maximum acceptable handling rate of 337 kg paraquat per individual worker per day
Backpack sprayer (a single operator mixes, loads and applies)	150 L/day (diluted product)	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	No Maximum acceptable handling rate of 0.3 kg of paraquat per individual worker per day
Manually pressurised hand wand application (a single operator mixes, loads and applies)	150 L/day (diluted product)	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	Restricted[3] Maximum acceptable handling rate of 10.4 kg of paraquat per individual worker per day
Mechanically pressurised hand wand application (a single operator mixes, loads and applies)	1,000 L/day spot treatment foliar (diluted product)	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	Restricted Maximum acceptable handling rate of 3.9 kg paraquat per individual worker per day
	4,000 L/day Broadcast foliar treatment (diluted product)		Restricted Maximum acceptable handling rate of 3.9 kg paraquat per individual worker per day

[3] Although mixer/loader exposure is acceptable with open mixing/loading with the specified PPE for certain uses, closed mixing/loading is required for all uses to minimise the likelihood of decanting into unacceptable containers which may lead to consequential accidental exposure.

Table 11: Risk assessment outcomes for liquid 135 g/L paraquat plus 115 g/L diquat products

Activity	Scale of Use	Minimum acceptable Personal Protective Equipment (PPE)[4]	Use Acceptable (Yes/No/Restricted)
Ground boom application mix, load and apply (a single operator mixes, loads and applies)	Small scale agriculture (up to 6 ha/day)	Open cab Single layer Gloves PF10 respirator Face shield or goggles when mixing or loading	Yes Maximum acceptable handling rate of 56 kg of diquat (487 L undiluted product) per individual worker per day
	Broad scale agriculture (up to 500 ha/day for all crops and 400 ha/d for cotton)	Enclosed cab application Enclosed mixing and loading (single layer of clothing, gloves, PF10 respirator, face shield or goggles when connecting, disconnecting or cleaning components of the mixing and loading system)	Yes Maximum acceptable handling rate of 317.7 kg of diquat (2763 L undiluted product) per individual worker per day
Backpack sprayer (a single operator mixes, loads and applies)	150 L/day (diluted product)	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	No* Maximum acceptable handling rate of 0.2 kg of diquat (1.74 L undiluted product) per individual worker per day
Manually pressurised hand wand application (a single operator mixes, loads and applies)	150 L/day (diluted product)	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	Yes Maximum acceptable handling rate of 8.2 kg of diquat (71.3 L undiluted product) per individual worker per day
Mechanically pressurised hand wand application (a single operator mixes, loads and applies)	1,000 L/day spot treatment foliar (diluted product)	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	Restricted Maximum acceptable handling rate of 2.3 kg diquat (20 L undiluted product) per individual worker per day
	4,000 L/day Broadcast foliar treatment (diluted product)		Restricted Maximum acceptable handling rate of 2.3 kg diquat (20 L undiluted product) per individual worker per day

*operator exposure for backpack use of combined paraquat and diquat products was not re-calculated as exposure to paraquat alone was not acceptable in any scenario

[4] Note that although mixer/loader exposure is acceptable with open mixing/loading with the specified PPE for certain uses, enclosed mixing/loading is required for all uses to minimise the likelihood of decanting into unacceptable containers which may lead to consequential accidental exposure.

4.1.2 Re-entry to treated areas

Based on the acute hazards associated with exposure to paraquat and diquat, treated areas should not be entered until the spray has dried unless using an enclosed cab or wearing cotton overalls and gloves. Workers performing scouting and hand-set irrigation activities must comply with the re-entry periods specified in Table 12, Table 13 or Table 14.

Table 12: Re-entry intervals for paraquat products

Activity	Non-Re-Entry Period (Days)1
Scouting (application rate of up to 500 g/ha)	0
Scouting (application rate of 501 to ≤ 600 g/ha)	1
Scouting (application rate of 601 to ≤ 750 g/ha) (optical spraying up to 2250 g/ha)2	3
Irrigation (hand set) (application rate of up to 300 g/ha)	0
Irrigation (hand set) (application rate of 301 to ≤ 400 g/ha)	3
Irrigation (hand set) (application rate of 401 to ≤ 500 g/ha)	5
Irrigation (hand set) (application rate of 501 to ≤ 600 g/ha)	7
Irrigation (hand set) (application rate of 601 to ≤ 750 g/ha) (optical spraying up to 2250 g/ha)2	9

[1]Day of spraying is Day 0.

[2]Optical spraying is considered to result in up to a 30% of a field being sprayed. Therefore, the optical spray label concentrations have been reduced by a factor of 70% for whole-of-field re-entry worker exposure considerations.

Table 13: Re-entry intervals for 135 g/L paraquat plus 115 g/L diquat products

Activity	Non-Re-Entry Period (Days)[1]
Scouting at application rate of up to 368 g diquat/ha	0
Irrigation (hand set) at application rate of up to 276 g diquat/ha	0
Irrigation (hand set) at application rate of 277 to ≤ 368 g diquat/ha	2

[1]Day of spraying is Day 0.

Table 14: Re-entry intervals for paraquat plus amitrole products

Activity	Non-Re-Entry Period (Days)[1]
Scouting at application rate of up to 510 g paraquat/ha (optical spraying up to 1680 g/ha)[2]	0
Scouting at application rate of 511 to ≤ 600 g paraquat/ha	1

Activity	Non-Re-Entry Period (Days)[1]
Scouting at application rate of 601 to ≤ 840 g paraquat/ha	5
Scouting at application rate of 841 to ≤ 1000 g paraquat/ha	6
Irrigation (hand set) at application rate of up to 510 g paraquat/ha (optical spraying up to 1680 g/ha)[2]	5
Irrigation (hand set) at application rate of 511 to ≤ 600 g paraquat/ha	7
Irrigation (hand set) at application rate of 601 to ≤ 840 g paraquat/ha	10
Irrigation (hand set) at application rate of 841 to ≤ 1000 g paraquat/ha	11

[1]Day of spraying is Day 0.

[2]Optical spraying is considered to result in up to a 30% of a field being sprayed. Therefore, the optical spray label concentrations have been reduced by a factor of 70% for whole-of-field re-entry worker exposure considerations.

4.1.3 Recommended label changes

The following changes to labels for products containing paraquat, or paraquat and diquat, are recommended to be applied as relevant to the use patterns that remain supported by all risk assessment outcomes.

4.1.3.1 Signal headings

All concentrations and formulations of paraquat are classified as a Schedule 7 poison. Supplementary labelling statements are required for paraquat, and the signal heading must read:

DANGEROUS POISON
KEEP OUT OF REACH OF CHILDREN
CAN KILL IF SWALLOWED
DO NOT PUT IN DRINK BOTTLES
KEEP LOCKED UP

The Poisons Standard also stipulates that paraquat products must be coloured blue or green and contain sufficient stenching agent to produce an offensive smell. All registered paraquat products currently comply with these requirements.

4.1.3.2 Restraints

4.1.3.2.1 General Restraints

DO NOT remove contents except for immediate use.

DO NOT apply by spraying equipment carried on the back of the user.

DO NOT continue to use if eye irritation or bleeding from the nose occurs.

DO NOT use open mixing/loading equipment. Closed mixing and loading MUST be used.

4.1.3.2.2 Restraints for specific uses

For broadacre boom spray applications:

DO NOT apply using open cab equipment. Enclosed cab application MUST be used.

For small scale agriculture (up to 6 ha per day)

DO NOT apply using open cab equipment unless using a PF10 respirator

For hand spray applications

DO NOT use hand wand sprays by spraying out of the window of a vehicle.

4.1.3.3 First aid statements (all products)

If poisoning occurs, get to a doctor or hospital quickly. If sprayed on skin, wash thoroughly. If sprayed in mouth, rinse mouth with water. If in eyes, hold eyes open, flood with water for at least 15 minutes and see a doctor.

4.1.3.4 Safety Directions (all products)

Very dangerous, particularly the concentrate. DO NOT swallow. The product, particularly the concentrate, can kill if swallowed, absorbed through the eyes, or absorbed by skin contact. The liquid can cause burns particularly to the eyes. Will irritate the nose, throat, and skin. When handling, DO NOT touch or rub eyes, nose or mouth with hand. Avoid contact with eyes and skin, open wounds, and clothing. Protect eyes while using. If clothing becomes contaminated with product or with wet spray remove clothing immediately. DO NOT inhale spray mist. DO NOT allow children to play with containers or any equipment that is used. When connecting, disconnecting and cleaning equipment wear cotton overalls buttoned to the neck and wrist (or equivalent clothing) and a washable hat, impervious footwear, elbow-length chemical resistant gloves and a full face respirator with canister specified for paraquat/diquat OR half face-piece respirator with canister specified for paraquat/diquat and face shield or goggles. When applying by low (manual pressurised) or high (mechanically pressurised) hand wand wear cotton overalls, over normal clothing, buttoned to the neck and wrist and a washable hat, impervious footwear, elbow-length chemical resistant gloves and a full face piece respirator with a canister specified for paraquat/diquat. After use and before eating, drinking or smoking, wash hands, arms and face thoroughly with soap and water. After each days use wash gloves, face shield or goggles, respirator (and if rubber wash with detergent and warm water), clothing and footwear.

4.1.3.5 Re-entry statements for paraquat products

DO NOT allow entry to treated areas until the spray has dried unless using an enclosed cab or wearing cotton overalls and gloves. Workers performing scouting and hand-set irrigation activities must comply with the re-entry periods specified in Table 12.

4.1.3.6 Re-entry statements for paraquat and diquat combination products

DO NOT allow entry to treated areas until the spray has dried unless using an enclosed cab or wearing cotton overalls and gloves. Workers performing scouting and irrigation activities must comply with the re-entry periods specified in Table 13.

4.1.3.7 Re-entry statements for paraquat and amitrole combination products

DO NOT allow entry to treated areas until the spray has dried unless using an enclosed cab or wearing cotton overalls and gloves. Workers performing scouting and irrigation activities must comply with the re-entry periods specified in Table 14.

5 Residues and Trade

This residues and trade assessment is completed as part of the paraquat reconsideration to determine if the current registered uses of paraquat are supported by residues data and continue to meet the statutory safety and trade criteria.

5.1 Metabolism

Metabolism data for plants, laboratory and food animals were considered.

Studies in plants (lettuce, carrot, potato, soybean and sugar cane) demonstrated that the dominant residue in plant material was parent paraquat (Slade, 1965; Calderbank and Slade, 1966; Slade and Bell, 1966; Slade, 1966(a,b); WHO, 1984). Pre-emergent use of paraquat at 14.3 – 14.7 kg ac/ha (greater than 20 times the maximum Australian label rate) produced residues in root and leafy vegetables less than the LOQ of analytical methods (Grout, 1994(a)). When paraquat was applied as a desiccant to potato and soy beans at 8.2 – 8.8 kg ac/ha, the predominant component in potato tuber, soy beans and soy foliage was paraquat (Grout, 1994(b); Grout, 1996). On foliage, a photodegradation product, N-methyl isonicotinic acid (MINA), also known as 4-Carboxy-1-methyl pyridinium ion (CMP) in older literature, is seen at low concentrations (0.3% TRR). Use as a desiccant on potatoes at 8.7-8.8 or 1.1 kg ac/ha (10 and 1.6 times maximum label rate produced paraquat residues in tubers of 0.08 and 0.06 mg/kg (Slade, 1966(a,b)).

Animal metabolism studies in rat, pig, sheep, lactating cow, lactating goat and the laying hen found that only small amounts of paraquat are absorbed from the gastrointestinal tract (GIT) and that there is minimal metabolism of the absorbed paraquat (Lythgoe and Howard, 1995(a, b, c); Hendley et al, 1976(a,b); MacPherson, 1995; Oliver and Hemingway, 1974(a,b)). Some studies failed to show the presence of any metabolites after oral administration of paraquat (Calderbank and McKenna, 1966, Stevens and Walley, 1965, 1966; Stevens et al, 1965; Daniel, 1971), while others have shown a small degree of metabolism (Hemmingway et al, 1972; Leahey et al, 1976, Spinks et al, 1976). Paraquat is excreted rapidly and largely unchanged, the large majority in the faeces (50.3% in goats) and a small amount in the urine (2.4% in goats) (Hendley et al, 1976). Residual radioactivity was primarily found in the liver (0.56 mg eq/kg in goat) and kidneys (0.74 mg eq/kg in goat)(Hendley et al, 1976(a)). Little paraquat was seen in muscle, fat, milk and eggs and even in studies conducted at exaggerated rates, residues in these tissues were less than 0.05 mg/kg (Slade, 1973; Leahey, 1975).

5.2 Analytical methods and storage stability

5.2.1 Analytical methods

Paraquat has been registered for many years and many analytical methods have been used for measuring residues of paraquat in plant and animal samples. Because paraquat is subject to limited metabolism in plants and animals, all the submitted methods are for determining paraquat only. These methods involve acid extraction of paraquat (not for liquid samples), filtration and clean-up by cation-exchange chromatography from which paraquat was eluted with saturated ammonium chloride. Some 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. Other methods determine paraquat in the “cleaned up” sample solution by reverse phase ion pair HPLC with UV detection at 258 nm.

Method RAM 272/02 for plant samples (Anderson and Boseley, 1995, 1997) and Method RAM 004/07 for animal samples (Anderson, 1994; Coombe, 1994; Anderson, 1997) were found to be suitable for the quantification of paraquat in plant and animal commodities. These methods were fully validated, include confirmatory techniques and recoveries were generally within acceptable limits (70-110%). The Limits of Quantification (LOQs) of these methods ranged from 0.01 to 0.05 mg/kg for plant commodities, except for straw for which the LOQ was up to 0.1 mg/kg and for oil cake, for which the LOQ was 0.5 mg/kg. For animal commodities the LOQs ranged from 0.005 – 0.01 mg/kg.

5.2.2 Stability of pesticide residues in stored analytical samples

Data were presented for stability of paraquat residues in carrot, cabbage, tomato, potato, banana, prune, wheat, corn, corn fodder, corn forage, corn silage, birdsfoot trefoil (forage and hay), coffee beans, milk, hen muscle and eggs that demonstrated that paraquat was stable when stored frozen at –15°C to –18°C (Earl et al, 1989(a); Roper, 1989a; Anderson, 1995; Coombe, 1995.

Data on tomato, potato, prune and corn were 12 month studies (Roper, 1989(b,c,d,e,f,g,h)), however the Joint FAO/WHO Meeting on Pesticide Residues (JMPR, 2004) evaluated 24 month storage data on the same commodities and found that the residues were stable with frozen storage for 24 months. Residues in cabbages and carrots were stable for 45 months. Residues in bananas and coffee beans were stable for 12 months, while residues in wheat were stable for 24 months. Studies with birdsfoot trefoil forage and hay were conducted over 25 weeks and demonstrated stability of incurred residues.

Stability studies demonstrated that paraquat residues were stable in chicken meat for 28 months, eggs for 29 months and milk for 13 months (Earl and Boseley, 1988(a, b); Anderson et al, 1991(a,b); Coombe, 1995).

Residue studies submitted for evaluation had stored samples under appropriate temperatures and time periods.

5.3 Residue definition

Due to little metabolism of paraquat in plants and animals, paraquat cation can be considered as the most appropriate residue definition for enforcement and risk assessment. This is consistent with the residue definition established overseas (see also the Trade section).

5.4 Residues in foods

The paraquat product labels have broad crop groupings for use patterns such as row crops, vegetables, market gardens and orchards. Paraquat, by virtue of its broad use pattern has lent itself to very general commodity groupings in the MRL standard such as fruits and vegetables.

The current practice is to support label claims and establish MRLs for commodity groups aligned with the Codex Commodity groups established by the FAO/WHO Codex Committee on Pesticide Residues (CCPR) and current APVMA crop group guidelines. Therefore, the current MRLs for fruits and vegetables and the expression of these crops on labels are being considered as part of this residues review.

5.4.1 Plant commodities

The use of paraquat can be broadly ascribed to 4 general categories:

- Pre-emergent or pre-sowing application
- Post-emergent directed application
- Post-emergent over the top spraying
- Pre-harvest desiccant application

These generalised use patterns have different residue potentials. The first 2, under most circumstances are expected to produce negligible residues in food commodities at commercial maturity. Post-emergent spraying of the crop may produce residues, but they would generally expected to be lower than those seen with pre-harvest desiccant uses that have very short withholding periods (WHPs).

5.4.1.1 Pre-emergent and pre-sowing use

Label rates for pre-emergent, pre-sowing or pre-planting application of paraquat range from 400 to 600 g ac/ha, with exception of the pre-emergent use in rice which involves a rate of 200 g ac/ha. The general crop groupings that have these uses on the label include: cereals; pulses; oilseeds; pasture; row crops; vegetables; market gardens and nurseries. Specific crops included on labels are: potato; rice and sugar cane.

Metabolism studies and residues trials, some at exaggerated application rates (up to 14.7 kg ac/ha or 20× the maximum label rate), have demonstrated non detectable residues in a large variety of crops and crop groups treated with pre-emergent or pre-sowing applications of paraquat (Grout, 1994) which indicates that residues in crops where paraquat has been applied as a pre-emergent or pre-sowing treatment would be expected to be less than the LOQ.

5.4.1.2 Post-emergent directed use

Directed applications of paraquat to weeds between rows of plants in orchards and vineyards, hops or produce in market gardens are unlikely to result in significant pesticide contact with produce being grown for human consumption. Metabolism studies and residue trials at rates in excess of Australian label rates demonstrated that residues will be non-detectable in a large variety of fruits and vegetables after directed inter-row spraying of paraquat. In orchard trials where residues have been detected, the method of application has been deliberate application to lower branches close to harvest, picking fallen fruit off recently sprayed ground or directly spraying fruit on the ground.

Use rates for post-harvest directed spraying in orchards (including walnuts) and vineyards are up to 0.8 kg ac/ha, for market gardens are up to 0.6 kg ac/ha and for hops are 0.4 kg ac/ha. The WHPs for these uses on current labels are ‘Not Required when used as directed’.

5.4.1.3 Post-emergent over the top spraying

Post emergence uses of direct spraying of crops are approved for sugar cane and pasture. In pasture residue trials have shown high residues at application rates up to 0.6 kg ac/ha.

5.4.1.4 Pre-harvest desiccant application

Australian labels have pre-harvest desiccation uses for potatoes and cotton and uses on pulses (chickpeas, faba beans, field peas, lentils, lupins and vetch) for reduction of seed set of annual ryegrass. Pre-harvest application for desiccation or reduction of seed set can be expected to produce significant residues in crops. Overseas, pre-harvest desiccation uses are also seen on some cereals, oilseeds, pulses and some other vegetables, but these uses are not on Australian paraquat product labels.

5.5 Fruit crops

The current MRL for fruit crops, listed as 'Fruits {except Olives}' is *0.05 mg/kg and includes all fruits on the labels from orchards (including bananas and vineyards) to market gardens and row crops and tropical fruits (avocado, custard apple, litchi and mango). In this assessment, separate MRLs for each of the codex groupings of fruits are proposed.

5.5.1 Pome fruit

The maximum Australian label rate is up to 0.8 kg ac/ha. Overseas residue data consisting of numerous trials from Canada, Germany and the United Kingdom (UK) on apples and pears treated at rates from 0.51 to 4.5 kg ac/ha found no paraquat residues above the LOQ of 0.01 mg/kg on fruit harvested from the trees with Post Harvest Intervals (PHIs) from 0 – 131 days (Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; Anon., 1971(a); Kennedy and French, 1981). Residues in apple pomace, which is an animal feed, were not addressed in the available trials however as residues were not observed in apple fruit, residues are not expected in processed apple commodities including pomace.

The available paraquat residues data supports continued use in pome fruit orchards. The MRL supported by this residues assessment for pome fruit is:

FP 0009 Pome Fruits	*0.01 mg/kg

As the use is directed to weeds and not the trees, a harvest withholding period statement of 'Not Required when used as directed' is supported for pome fruit.

5.5.2 Citrus fruit

The maximum Australian label rate is up to 0.8 kg ac/ha. Overseas residue data consisting of numerous trials from the United States of America (USA) and Italy on oranges, grapefruit, lemons and limes treated at rates from 0.8 to 2.44 kg ac/ha found no paraquat residues above the LOQ (0.01 – 0.05 mg/kg) on fruit harvested from the trees at PHIs from 0 – 177 days (Anon., n.d.(a); Dick et al, 1995; Reeve, 1970). Residues were also not detected in juice, peel or pulp, which is an animal feed commodity.

The available paraquat residues data supports continued use in in citrus orchards. The recommended entry into the MRL Standard for citrus fruit is as follows noting that the majority of trials addressed the LOQ of 0.01 mg/kg:

FC 0001 Citrus Fruits	*0.01 mg/kg

As the use is directed to weeds and not the trees, a harvest withholding period statement of 'Not Required when used as directed' is supported for citrus fruit.

5.5.3 Stone fruit

The maximum Australian label rate is up to 0.8 kg ac/ha. Overseas residue data consisting of numerous trials from Canada, Germany and the UK on apricots, plums, peaches and cherries treated at rates which ranged from 1.0 to 4.5 kg ac/ha found no paraquat residues above the LOQ (0.01 mg/kg) on fruit harvested from the trees at PHIs from 9 – 87 days. Residues were not detected in dried prunes (Calderbank and McKenna, 1964, Anon., 1971(a); Anon., n.d.(b); Roper, 1989(i)).

The available paraquat residues data supports continued use in in stone fruit orchards. The recommended entry into the MRL Standard for stone fruit is:

FS 0012 Stone Fruits	*0.01 mg/kg

As the use is directed to weeds and not the trees, a harvest withholding period statement of 'Not Required when used as directed' is supported for stone fruit.

5.5.4 Berries and other small fruits

The maximum Australian label rate for vineyards is up to 0.8 kg ac/ha. Overseas residue data consisting of numerous trials from Canada, Japan, Switzerland and the USA on vineyards treated once or twice at rates which ranged from 0.3 to 4.4 kg ac/ha found no paraquat residues above the LOQ (0.01 mg/kg) on fruit harvested from the grape vines at PHIs from 0 - 196 days. No residues were detected in sun dried grapes or juice from grapes treated at 5.6 kg ac/ha (Edwards, 1974; Earl and Anderson, 1992; Anon., 1971(a)).

The maximum Australian label rate is up to 0.6 kg ac/ha for row crops and market gardens which may include berries and other small fruit, except for grapes (covered by the vineyard use). Overseas residue data which consisted of numerous trials from Canada, Ireland and the USA on blueberries, blackberries, blackcurrants, redcurrants, loganberries, cranberries, gooseberries, raspberries and strawberries treated once or twice at rates which ranged from 0.42 to 4.5 ac/ha found no paraquat residues above the LOQ (0.01 mg/kg) in fruit at PHIs from 1 – 210 days (Calderbank and McKenna, 1964; Anon. n.d.(b); Anon., 1967).

The available paraquat residues data supports continued use in grapes (vineyards) and other members of the berries and other small fruit crop group. The recommended entry into the MRL Standard for berries and small fruits, including grapes is:

FB 0018 Berries and other small fruits	*0.01 mg/kg

As the use is targeting inter-row weeds and not the crop, a harvest withholding period statement of 'Not Required when used as directed' is supported for berries and other small fruit.

5.5.5 Tropical fruits – inedible peel

The maximum Australian label rate for use in orchards which may include all crops within the tropical fruit with inedible peel crop group except for pineapple is up to 0.8 kg ac/ha. For use in row crop, which may include pineapple, the maximum label rate is 0.6 kg ac/ha The Australian labels also have a specific use pattern for avocados, custard apples, litchis and mangoes at 32.4 g ac/100 L (or 0.324 kg ac/ha with an assumed spray volume of 1000 L/ha).

Overseas residue data on bananas from Honduras and pineapples from Hawaii which involved one to 3 applications at rates between 0.55 and 4.5 kg ac/ha found no paraquat residues above the LOQ (0.01 mg/kg) in fruit at PHIs from 0 – 501 days (Anon., 1973; Anon., 1965 (a,b)).

No data was submitted for tropical fruit with inedible peel, except for banana and pineapple. In light of the extensive data presented for pineapple, bananas and other fruit trees, the weight of evidence demonstrates that directed spraying of weeds around tropical fruit with inedible peel trees with paraquat is unlikely to result in quantifiable residues in the fruit.

The available paraquat residues data supports continued use in tropical fruit with inedible peel which was covered by the label claim for orchards, the use in pineapples which was covered by the label claim for row crops and the specific use for avocados, custard apples, litchis and mangoes (2 application, 14 days apart at 32.4 g ac/100L). The recommended entry into the MRL Standard for tropical fruits – inedible peel is:

FI 0030 Assorted tropical and subtropical fruits – inedible peel *0.01 mg/kg

As application is to the ground cover underneath the tree or to inter row weeds and not the crop, a withholding period of “Not required when used as directed” is appropriate.

5.5.6 Tropical fruits – edible peel

The maximum Australian label rate is up to 0.8 kg ac/ha for olives and other tropical fruit with edible peel (orchard crops). Overseas residue data from Italy, Spain and the USA on olives which involved one to 4 applications at rates between 0.36 and 5.6 kg ac/ha found no paraquat residues above the LOQ (0.01, 0.05 or 0.1 mg/kg) on fruit harvested from the trees at PHIs from 0 – 21 days. No residues of paraquat were detected in olive oil (Anon., 1987; Roper, 1989(j); Anderson and Earl, 1993; Dick et al, 1995(b); Anon., 1973; Massey, 1987(a); Kennedy, 1987).

A North American processing study in figs at rates of 1.1 to 5.5 kg ac/ha found no paraquat residues above the LOQ in figs (0.01 mg/kg for fresh figs, 0.05 mg/kg for dried figs) at PHIs of 13-14 days (Roper, 1989(k)).

Residue trials on olives, figs and a variety of fruit trees has shown that residues would not be found in fruit harvested from trees in orchards that have been treated with directed applications of paraquat. On this basis a MRL for the whole group, tropical fruits edible peel, can be established at the LOQ of *0.05 mg/kg noting that while a LOQ’s in the available olive and fig trials ranged from 0.01 to 0.1 mg/kg, and 0.05 mg/kg was the most common LOQ.

The recommended entry into the MRL Standard for tropical fruits – edible peel is:

FT 0026 Assorted tropical and subtropical fruits – edible peel *0.05 mg/kg

The available paraquat residues data supports continued use in tropical fruit with edible peel. The current MRL for olives at 1 mg/kg can be deleted. Residues in table olives will be covered by this recommended MRL however olives for oil production (SO 0305) will be covered by the oilseed MRL at the same level recommended below.

As application is to the ground cover underneath the tree, a withholding period of “Not required when used as directed” is appropriate.

5.5.7 Tree nuts

The maximum Australian label rate for orchards (including tree nuts) and for the specific use on walnuts is up to 0.8 kg ac/ha. Overseas residue data from Canada, Italy and the USA on almonds, pecans, macadamias, pistachios, walnuts and hazelnuts which involved one to 8 applications at rates between 0.54 to 4.55 kg ac/ha found no paraquat residues above the LOQ (0.01 mg/kg) on nuts harvested from the trees (PHI 1 – 73 days) (Anon., n.d.(b); Anon., 1965(c); Anon., 1966; Anon., 1971(b); Anon., 1977, Anon., 1987).

Residues were detected in some nuts that were picked of the ground that had been sprayed a day before or sprayed directly whilst on the ground and from nuts that were picked of branches that were directly sprayed 3 days before picking. While almonds may be harvested from the ground, it would not be considered good agricultural practice to treat weeds 0 - 3 days before harvest. Residues were generally <0.01 mg/kg in nuts sampled at longer PHIs 4 – 73 days (all <LOQ (0.01 to 0.05 mg/kg)).

Data for detections in almonds were also provided by the NRS in relation to MRLs set for almonds in key markets. The highest residue detected in almonds was 0.10 mg/kg, with all other detections in the range 0.01 – 0.04 mg/kg. While the data do not indicate an undue trade risk with the Codex paraquat Tree nuts MRL at 0.05 mg/kg, the low detections do suggest it may be prudent to retain the APVMA paraquat TN 0085 Tree nuts MRL at *0.05 mg/kg, rather than the suggested change to *0.01 mg/kg which was originally recommended in the earlier evaluation. It is noted that almonds are not currently considered to be a major export commodity.

The available paraquat residues data supports continued use in tree nuts. The recommended entry into the MRL Standard for tree nuts is:

TN 0085 Tree nuts *0.05 mg/kg

As application is to the ground cover underneath the tree, a withholding period of “Not required when used as directed” is appropriate for tree nuts.

5.6 Vegetable crops

The current MRL for vegetables [except potato and pulses] is *0.05 mg/kg. The general vegetable MRL will be broken down to separate MRLs for the various codex classifications of vegetables.

Application rates for ‘Row crops, vegetables, market gardens, nurseries’, which is considered to cover all vegetables (except pulses), are ‘0.4 to 0.432 kg ac/ha or 50 g ac/100 L’ for pre-emergent spraying and up to 0.6 kg ac/ha for post-emergence directed inter-row spraying. As a worst case, the maximum rate is considered to be 0.5

kg ac/ha (50 g ac/100 L for an assumed spray volume of 1000 L/ha) for pre-emergence spraying. Potatoes also have a pre-harvest desiccant application rate up to 0.7 kg ac/ha. Pulses (chickpeas, faba beans, field peas, lentils, lupins and vetch) in general have a post-emergence use rate of 0.2 kg ac/ha.

5.6.1 Bulb vegetables

The maximum Australian label rate for vegetables is up to 0.6 kg ac/ha. Overseas residue data from Canada, Germany and the UK on bulb onions and spring onions involved one to 4 applications at 0.66 to 2.24 kg ac/ha.

Trials which best approximated Australian use rates, namely: 0.75; 0.66 + 0.96; 0.75 + 1, had residues at or less than the LOQ of 0.01 or 0.02 mg/kg (depending on the trial) (Anon. n.d.(h); Calderbank and Yuan, 1963; Reeve, 1970; Edwards, 1974; Swaine, 1983(a); Kennedy, 1984(a); Anon., 1985; Massey; 1987(b)). These trials demonstrated that residues should be <LOQ (0.01 or 0.02 mg/kg) in bulb vegetables following application at the label rate for vegetables (0.6 kg ac/ha) at PHI’s ranging from 0 – 143 days and therefore a LOQ MRL recommended.

The available paraquat residues data supports continued use in bulb vegetables. The recommended entry into the MRL Standard for bulb vegetables is as follows noting that the majority of trials addressed the LOQ of 0.01 mg/kg:

VA 0035 Bulb vegetables	*0.01 mg/kg

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for bulb vegetables.

5.6.2 Root and tuber vegetables

The maximum Australian label rate for pre-emergence and directed spray uses in vegetables is up to 0.6 kg ac/ha. Potatoes have an additional label use to the rest of the group, namely a pre-harvest weed control application rate up to 0.7 kg ac/ha.

Relevant to the pre-harvest use in potatoes, residues data from the UK, Canada and the USA involved pre-harvest treatment at rates ranging from 0.2 to 6.27 kg ac/ha. Residues in potato tubers were <LOQ (0.01 mg/kg) to 0.2 mg/kg at PHI’s of 14 to 41 days (Anon., n.d.(i), Calderbank and McKenna, 1964; Reeve, 1970; Anon., 1970 (a); Anon., 1971(a); Anon., 1974; Kennedy, 1984(a); Anon. 1985; Roper, 1989(m); Earl and Anderson 1991). Scaled to application rate the high residue (HR) for potatoes is 0.13 mg/kg (at a 14 day PHI).

Some Australian labels indicate that applications should be made 3 to 7 days before digging. There is sufficient data relevant to an application timing of 14 days before digging (10 results for application at 1.12 kg ac/ha, 14 day PHI), however, the scaled HR (0.13 mg/kg) would give an unacceptable acute dietary exposure for children (111% of ARfD). New data for a 7 day PHI provided in response to the initial consultation but has a similar high residue (0.14 mg/kg scaled) as the previously submitted 14 day PHI data. The results of a market basket survey conducted in the USA in 2004/05 were also submitted. While the residue detected in potatoes in this survey would give an acceptable acute dietary exposure estimate, it is not appropriate to use residue survey data to address acute dietary exposure concerns, noting also that the market basket survey was not conducted in Australia and is also approximately 20 years old. Application to potatoes 14 days (or less) before digging therefore cannot be supported due to acute consumer safety concerns.

For the alternative pre-harvest potato Good Agricultural Practice (GAP) on some labels which allows application to potatoes at 4-5 weeks before digging, the current MRL of 0.2 mg/kg would remain appropriate based on available data that addressed a 27-31 day PHI. Based on the HR of 0.09 mg/kg at a 27–31 day PHI, the acute dietary exposure is estimated to be acceptable for potatoes (77% of the ARfD for children and 32% of ARfD for general population). This use on potatoes 4-5 weeks before digging remains appropriate in conjunction with a harvest withholding period of "Not required when used as directed". The current MRL at 0.2 mg/kg for potatoes remains appropriate.

Labels that currently have the '3 to 7 days before digging and after tops have died down' instruction must be changed to state that application must occur '4-5 weeks before digging'.

Relevant to the pre-emergence and directed spray uses on potatoes and other root and tuber vegetables, overseas residue data from the UK, Canada, the USA, Germany, South Africa, Japan and France on potatoes, beetroot, carrots, parsnip, swedes, turnip and black salsify addressed rates ranging from 0.28 to 2.24 kg ac/ha. Pre-emergent and post-emergent directed applications of paraquat to potatoes, beetroot, carrot, parsnip, turnip and black salsify resulted in residues in the roots and tubers at <LOQ (0.01 – 0.05 mg/kg) when scaled to the Australian rate (0.6 kg ac/ha) (Calderbank and McKenna, 1964; Edwards, 1974; Anon., n.d.(i) Kennedy, 1984(b); Earl and Anderson 1991; Anon., 1974; Reeve, 1970; Anon., 1970 (a); Anon., 1971(a); Anon. 1985; Roper, 1989(m, n)).

The available paraquat residues data for root and tuber vegetables supports continued use as a pre-emergence and directed spray in all root and tuber vegetables and as a pre-harvest application to potatoes 4–5 weeks before digging. The recommended entries into the MRL Standard for root and tuber vegetables is as follows noting that the majority of trials addressed the LOQ of 0.01 mg/kg:

VR 0589 Potato	0.2 mg/kg
VR 0075 Root and tuber vegetables {except Potatoes}	*0.01 mg/kg

For the pre-emergence and directed spray use in root and tuber vegetables, a harvest withholding period statement of 'Not Required when used as directed' is supported as the use is pre-emergent or targets inter-row weeds and not the crop. The 'Not Required when used as directed' withholding period statement is also considered appropriate for the pre-harvest spray given that the pre-harvest application should be made 4–5 weeks before digging.

5.6.3 Leafy vegetables

The maximum Australian label rate for vegetables is up to 0.6 kg ac/ha. Overseas residue data from Germany, the UK and the USA on lettuce treated at rates ranging from 0.5 to 0.97 kg ac/ha found no paraquat residues above the LOQ (0.01 or 0.02 mg/kg). Trials on lettuce, turnip tops and kale at rates in excess of 1 kg ac/ha did detect residues at time of harvest but these generally were less than 0.01 mg/kg when scaled for the proposed rate or were from samples collected at very short PHI's (Anon., n.d; Kennedy, 1984(a); Roper, 1989(o); Swaine, 1983(b); Massey, 1987(c,d)).

Although data was available only for lettuce for Australian GAP, use in the leafy vegetable crop group can be supported based upon the pattern of non-detects in a large variety of vegetable produce with directed inter row application of paraquat. The recommended entry into the MRL Standard for leafy vegetables is:

VA 0035 Leafy vegetables *0.02 mg/kg

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for leafy vegetables.

5.6.4 Brassica vegetables

The maximum Australian label rate for vegetables is up to 0.6 kg ac/ha. Overseas residue data from Japan, Canada and the Netherlands on cabbage, broccoli and cauliflower treated at rates ranging from 0.96 to 2.24 kg ac/ha all found no paraquat residues above the LOQ (0.01 or 0.03 mg/kg) with exception of a cabbage trial conducted at 2.24 mg/kg which found a residue of 0.09 mg/kg which would be below the LOQ of 0.03 mg/kg when corrected to the Australian rate (0.6 kg ac/ha)(Edwards, 1974; Anon., n.d.(b)).

The available paraquat residues data supports continued use in brassica vegetables. The recommended entry into the MRL Standard for brassica vegetables is:

VB 0040 Brassica vegetables *0.03 mg/kg

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for brassica vegetables.

5.6.5 Stalk and stem vegetables

The maximum Australian label rate for vegetables is up to 0.6 kg ac/ha. Overseas residue data from Canada on asparagus and celery treated at rates of 1.12 or 2.24 kg ac/ha found residues to be less than the LOQ of 0.05 mg/kg in most trials (Calderbank and McKenna, 1964; Anon., n.d.(b)). When scaled for the Australian rate (0.6 kg ac/ha) the high residue of 0.07 mg/kg is below the LOQ.

The available paraquat residues data supports continued use in stalk and stem vegetables. The recommended entry into the MRL Standard for stalk and stem vegetables is:

VS 0078 Stalk and stem vegetables *0.05 mg/kg

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for stalk and stem vegetables.

5.6.6 Fruiting vegetables, cucurbits

The maximum Australian label rate for vegetables is up to 0.6 kg ac/ha. Overseas residue data from the USA on cucumber, summer squash (zucchini), and melons (including watermelon) treated one to 4 times at rates ranging from 0.56 to 1.12 kg ac/ha found no paraquat residues above the LOQ (0.01 to 0.03 mg/kg)(Roper, 1989(p), Reeve, 1970).

The available paraquat residues data supports continued use in cucurbits. The recommended entry into the MRL Standard for fruiting vegetables, cucurbits is:

VC 0045 Fruiting vegetables, cucurbits *0.03 mg/kg

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of 'Not Required when used as directed' is supported for cucurbit vegetables.

5.6.7 Fruiting vegetables, other than cucurbits

The maximum Australian label rate for vegetables is up to 0.6 kg ac/ha. Overseas residue data from Canada and the USA at 0.11 to 0.22 kg ac/ha in one tomato trial or rates ranging from 1.12 to 11.2 kg ac/ha on tomatoes and peppers treated found no paraquat residues above the LOQ (0.005 mg/kg or 0.01 mg/kg) (Calderbank and McKenna, 1964; Edwards, 1974; Roper 1989(q,r).

The available paraquat residues data support continued use in fruiting vegetables. The recommended entry into the MRL Standard for fruiting vegetables, other than cucurbits is:

VO 0050 Fruiting vegetables, other than cucurbits *0.01 mg/kg

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of 'Not Required when used as directed' is supported for fruiting vegetables.

5.6.8 Legume vegetables

The maximum Australian label rate for vegetables is up to 0.6 kg ac/ha. Overseas residue data from Canada, Guatemala and the UK on a variety of beans and peas treated at post-emergence application rate from 0.14 to 2.24 kg ac/ha found no paraquat residues above the LOQ (0.01 to 0.05 mg/kg) (Calderbank and McKenna, 1964; Edwards, 1974; Anon., n.d.(b); Kennedy, 1984; Anon. 1985; Anon. n.d.(b)).

The available paraquat residues data support continued use in legume vegetables. The recommended entry into the MRL Standard for legume vegetables is:

VP 0060 Legume vegetables *0.05 mg/kg

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of 'Not Required when used as directed' is supported for legume vegetables.

5.7 Pulses

Paraquat has registered uses in pulses (under the vegetables label claim or cultivation aid label claim on paraquat and diquat combination products) as a pre-emergence herbicide (0.4-0.6 kg ac/ha) or spray topping treatment to reduce seed set of ryegrass weeds (0.2 kg ac/ha) in chickpeas, faba beans, field peas and lupins with a WHP of 7 or 14 days.

Australian trials which addressed the spray topping use were submitted on field peas, chickpeas and lupins at 0.2 and 0.4 kg ac/ha. Trials on soybeans which addressed a pre-harvest desiccant treatment (which is not on Australian labels for soybeans) or a pre-emergent application at 1.12 kg ac/ha (Roper, 1989(s). The current MRL for pulses is 1 mg/kg for the whole group.

Soybean trials with pre-emergence applications at 1.12 kg ac/ha did not detect any residues above the LOQ (0.05 mg/kg in the majority of trials)(Roper, 1989(t,u); Anon., 1972(a); Anon., 1978; Hayward and Robbins, 1981; Kennedy and Robbins, 1982; Hayward and Robbins, 1981; Kennedy et al,1983; Earl and Muir, 1988; Roper, 1993; Roper and Elvira, 1996(a)).

This data supports an MRL of *0.05 mg/kg for pulse crops which only have an approved pre-emergent use vegetables label claim or cultivation aid label claim on paraquat and diquat combination products.

Australian trials with chickpeas, field peas and lupins at 0.2 and 0.4 kg ac/ha found residues in seed were up to 0.41 mg/kg at the label rate and up to 0.54 mg/kg at double the maximum application rate following a 14 day PHI. Residues at 14-15 day PHI (or later if higher) following one application at 0.2 kg ac/ha were 0.05, 0.1, 0.31 and 0.41 mg/kg (Roy, 1973; Marcus, 1993 (a,b,c) Brown, 1994 (a,b,c)). The OECD MRL calculator estimates an MRL of 0.9 mg/kg based on this dataset (STMR 0.21 mg/kg). This data supports an MRL a 1 mg/kg for chickpeas, faba beans, field peas, lentils and lupins which have an approved spray topping use noting that data for chickpeas and field peas are relevant to other dried peas (i.e. lentils) while data for lupins are relevant to other dried beans (i.e. faba beans). The MRL for other pulses that only have a pre-emergent use will be *0.05 mg/kg for ‘Pulses {except Broad bean (dry); Chick-pea (dry); Field pea (dry); Lentil (dry); Lupin (dry)}.

The available paraquat residues data support continued use in pulses. This data supports a 14 day withholding period for the spray toping use at 0.2 kg ac/ha for chickpeas, faba beans, field peas, lentils and lupins. For labels with a 7 day withholding period for this use pattern, the withholding period should be changed to 14 days as there was insufficient residues data addressing a 7 day withholding period. Responses were received to the initial consultation requesting that the 7 day harvest withholding period for the spray topping use should remain in place based on the data for pulses published by the National Residue Survey (NRS). One response indicated that across the 1,255 samples tested by the NRS (lentils, chickpeas, field peas and faba beans) nationally, over the reported 10-year period, one hundred percent were below the Australian 1 mg/kg. While the NRS data shows a high compliance with the pulse MRL, there is no information on how the crops were treated and the time between treatment and harvest. It is not considered good practice to set an MRL in conjunction with a withholding period based on survey data. The supported withholding period for the spray topping use on selected pulses remains 14 days. For other pulses the supported withholding period is “Not required when used as directed” as the use would be pre-emergent or directed to inter row weeds.

The recommended entries into the MRL Standard for pulses are as follows noting that the most common LOQ in the available pulse trials was 0.05 mg/kg:

VD 0070 Pulses {except Broad bean (dry); Chick-pea (dry); Field pea (dry); Lentil (dry); Lupin (dry)}	*0.05 mg/kg
VD 0523 Broad bean (dry) [faba bean (dry)]	1 mg/kg
VD 0524 Chick-pea (dry)	1 mg/kg

VD 0561 Field pea (dry)	1 mg/kg
VD 0533 Lentil (dry)	1 mg/kg
VD 0545 Lupin (dry)	1 mg/kg

5.8 Cereals

In Australia the maximum rate for cereals is 0.6 kg ac/ha as pre-sowing cultivation aid application. Rice has a separate entry on some Australian labels with a pre-sowing maximum rate of 0.4 kg ac/ha and a pre-emergent maximum rate at 0.2 kg ac/ha. Australian trials on rice, wheat and barley were submitted along with overseas trials from a range of countries on sorghum, rice, corn, wheat, barley, oats and buckwheat. The current MRL for cereals (except maize and rice) is *0.05 mg/kg with MRLs for maize being 0.1 mg/kg, rice being 10 mg/kg and polished rice being 0.5 mg/kg.

Sorghum trials with pre-emergence treatment at 1.12 kg ac/ha combined with post-emergence application at 0.56 kg ac/ha did not detect paraquat residues above the LOQ (0.025 mg/kg) in grain (Anon., n.d.(d); Anon., 1970 (b,c)); Ward, 1979; Roper, 1989 (w)).

No paraquat residues above the LOQ (0.05 mg/kg) were detected in rice grain in trials that involved rates ranging from 0.13 to 1 kg ac/ha (Anderson et al, 1995; Reeve, 1970) Anon., 1972 (b,c); Kennedy, 1984(c)). The current MRL of 10 mg/kg for rice is based upon a pre-harvest use on rice which is not on current labels.

Pre-emergence and pre-sowing use patterns at rates ranging from 0.28 to 1.12 kg ac/ha did not detect residues above the LOQ (0.01 to 0.05 mg/kg) in maize/corn (Calderbank and McKenna, 1964; Anon., n.d.(a) Anderson and Lant,1994; Reeve, 1970; Kennedy, 1984(d); Roper, 1989 (x)).

Pre-emergence trials on wheat, barley and oats did not detect residues above the LOQ (0.01 to 0.05 mg/kg) in grain after application at 1.12 – 5.6 kg ac/ha (up to 9× the proposed rate) (Calderbank and McKenna, 1964; Roper, 1989(y); Reeve, 1970; Reeve, 1972; Brown, 1994(d,e)).

The available paraquat residues data support continued use in cereals. As the use pattern for all cereals is a pre-emergent/pre-sowing use pattern no paraquat residues above the LOQ in seed is expected or was found in residue trials. Therefore, a single entry can be established for the whole group at *0.05 mg/kg whilst deleting the existing MRLs for rice, polished rice and maize.

The recommended entry into the MRL Standard for cereals is as follows noting that the most common LOQ in the available cereal trials was 0.05 mg/kg:

GC 0080 Cereal grains	*0.05 mg/kg

A harvest withholding period statement of ‘NOT required when used as directed’ is appropriate for cereals as the use is pre-sowing or post sowing / pre-crop emergence.

A publicly available journal article by Gupta et al (Environmental Science and Pollution Research (2023) 30:54242–54243) was submitted in response to the initial consultation explored paraquat residues in wheat grain in field experiments conducted in India from 2018 - 2020. Paraquat was applied prior to sowing of wheat over two seasons each at rates corresponding to 1.02 kg ai/ha. The article indicated that they found paraquat in wheat grains ranging between 21.6 and 49.02 mg/kg with residues also found in the control crop (3.1 mg/kg). This is inconsistent with the cereal residue trials presented to the review where pre-emergence trials on wheat, barley and oats did not detect residues above the LOQ (0.01 to 0.05 mg/kg) in grain after application at 1.12 – 5.6 kg ai/ha (up to 9× the current rate).

It is also noted that data for cereal grains reported by the National Residue Survey does not show paraquat residues in cereals at the levels reported in the journal article. The non-GLP journal article is not considered to be a reliable measure of potential residues in wheat grain from the registered uses of paraquat.

5.9 Oilseeds

Current Australian use patterns differ amongst the oilseeds. All oilseeds have a pre-emergent use as a cultivation aid at up to 0.6 kg ac/ha. Cotton has an additional pre-harvest desiccant application at 0.216 kg ac/ha with a WHP of 7 days. Peanuts have an additional post-emergent application (up to 7–8 leaf stage) at 0.25 kg ac/ha.

5.9.1 Cotton

An Australian study found that that the spray topping use at 0.4 kg ac/ha (1.9x the label rate) resulted in residues <0.1 mg/kg (n=2) in cotton seed after the current 7 day WHP (Roper and Elvira, 1996(b)). Additional relevant pre-harvest desiccation application cotton trials presented in the 2004 JMPR indicate that at Australian GAP, finite residues could be expected in cotton seed (Roper, 1994; Roper, 1990; Brown and Marcus, 1996). At a WHP of 7 days after pre-harvest applications at 0.14 to 0.28 kg ac/ha, residues in cotton seed would be expected to be less than 0.2 mg/kg.

The available paraquat residues data support continued use in cotton. The current and recommended entry into the MRL Standard for cotton is:

SO 0691 Cotton seed	0.2 mg/kg

The current entry for cotton seed oil of 0.05 mg/kg in the MRL Standard can be deleted (see Section 2.4.7).

A 7 day withholding period is supported for the desiccation use pattern on cotton.

5.9.2 Peanuts

Two Australian residue trials for peanuts were submitted for review. No paraquat residues above the LOQ (0.01 mg/kg) were seen in peanut kernels or nuts in shell at post-emergent application rates up to 0.6 kg ac/ha (Williams, 1989 (a,b)). The maximum label rate for post-emergent application is 0.25 kg ac/ha.

The available paraquat residues data support continued use in peanuts. The current Australian MRL of *0.01 mg/kg in peanuts is not considered necessary as the recommended MRL for ‘Oilseeds {except Cotton seed}’ below at *0.05 mg/kg will cover this use on peanuts.

SO 0088 Oilseed {except Cotton seed}	*0.01 mg/kg

A current harvest withholding period statement of 'NOT required when used as directed' is appropriate as the use is only permitted up to the 7–8 leaf stage.

5.9.3 Oilseeds other than cotton and peanuts

The current product labels only have a pre-emergent use pattern for oilseeds. Only a US trial on sunflowers provided data on pre-emergent application of paraquat. Even though the application rates were 2.5 to 12 times the maximum Australian label rate no paraquat residues above the LOQ were detected in seed (LOQ 0.05 mg/kg) (Roper, 1989 (v); Wilde, 1978; Ward, 1979; Cowdy, 1976; Roper, 1995; Anon., n.d.(c); Marcus, 1996).

The available paraquat residues data support continued pre-emergent use in oilseeds. A LOQ MRL at *0.05 mg/kg is recommended for 'Oilseeds {except Cotton seed}. A harvest withholding period statement of 'NOT required when used as directed' is appropriate as the use is pre-sowing.

5.10 Sugar cane

Australian label rates for sugar cane are: 0.432 kg ac/ha for pre-sowing applications; and 0.4 kg ac/ha for post-emergent treatments which include over the top spraying of cane at the 3 to 4 leaf stage and directed inter-row spraying after cane has reached the ¾ leaf stage. The current Australian MRL for cane is *0.05 mg/kg.

Available data for sugarcane consists of Argentinian trials involving a pre-harvest treatment 7 days before harvest (Anon., n.d.(b)). Suitable trial data reflective of the Australian pre-emergent, post emergent or inter-row treatments have not been submitted for sugar cane. Data on the post-emergent application, particularly the over-the-top spraying are required to support this specific use pattern.

Metabolism data indicate that pre-emergent or post-emergent directed spraying is unlikely to result in detectable residues in sugar cane (California Chemical Company, 1965). A plethora of pre-emergent data for fruits, vegetables, cereals and oilseeds supports the conclusion that residues above the LOQ should not occur in sugar cane at harvest following the pre-emergent or directed (inter-row) treatment and these uses therefore can be supported from a residue's perspective.

However, Australian labels currently include over the top spraying at 3-4 leaf stage. Post emergent applications can result in direct contact with plants and can potentially result in quantifiable residues. The continued post-emergent use on sugar cane initially was not supported from a Residues and Trade perspective due to a lack of residues data relevant to that use pattern.

In response to the initial consultation, 4 studies conducted on sugar cane grown in Brazil were submitted. Two studies were relevant involving application at 600 g ai/ha (1.5×) at BBCH 23-36 (i.e. after leaf development) in one study or 7-8 leaves in the other. Both application timings are later than previously allowed. Residues were <0.01 (4) and <0.05 (2) mg/kg, i.e. below the respective study LOQ. The previously allowed over the top post-emergent application to sugar cane up the 3 to 4 leaf stage can therefore now be supported without any changes required to the current MRL of *0.05 mg/kg for paraquat on GS 0659 Sugar cane. Based on the residue data considered previously for other grass crops, the paraquat primary feed commodities MRL at 500 mg/kg should be sufficient to cover residues in sugarcane forage and fodder at a 1 day grazing withholding period for this over-the-top use, noting the higher biomass for sugarcane compared to other grasses.

5.11 Hops

The maximum Australian label rate is up to 0.4 kg ac/ha for hops. The current MRL for hops is 0.2 mg/kg. Overseas trial data from Canada, Germany and the USA on hops treated at 1 to 2.8 kg ac/ha found no paraquat residues above the LOQ (0.01, 0.05 or 0.1 mg/kg) mg/kg in dried and fresh hops. No residues were detected in processed hops treated at 2.8 kg ac/ha. In Australian data for hops, paraquat residues were <0.05 mg/kg (n = 2) at 12 – 14 days after 2-3 applications at 432 g ac/ha by inter row boom spray (Anon., n.d.(b); Roper, 1989(l); Anon., 1979).

The available paraquat residues data support continued use in hops. The recommended entry into the MRL Standard for hops is as follows noting that the LOQ in the majority of hops trials was 0.05 mg/kg:

DH 1100 Hops, dry	*0.05 mg/kg

As the use is targeting inter-row weeds and not the crop, a harvest withholding period statement of 'Not required when used as directed' is supported for hops.

5.12 Herbs and spices

No residues data for herbs and spices have been provided.

Herbs and spices are also grown in market gardens and hence have a potential label use pattern; namely that of a pre-planting/pre-emergent application up to 0.5 kg ac/ha and post-emergent directed spray at up to 0.6 kg ac/ha. Data for pre-emergent use in a plethora of fruit, vegetable, cereal and oilseed crops, including leafy vegetables which are physiologically similar to herbs, show that no detectable residues would be expected under these pre-emergent use patterns and hence MRL at the LOQ of *0.05 mg/kg can be considered for herbs and spices.

As the use is pre-emergent or targets inter-row weeds and not the crop, a harvest withholding period statement of 'Not required when used as directed' is supported for herbs and spices.

The recommended entry into the MRL Standard for herbs and spices are:

HH 0092 Herbs	*0.05 mg/kg
HS 0093 Spices	*0.05 mg/kg

5.13 Processed commodities

Processing data demonstrated that residues of paraquat in major food processed items (flour, peeled potatoes, malt, sugar, oil, juice and beer) can be reduced by processing.

Data from processing studies demonstrated that paraquat does not concentrate in oil produced from cereal grains, oilseeds or olives. Application at label rates to cereals, olives and oilseeds is unlikely to produce detectable residues in oil (Anon., 1973; Kennedy, 1985; Roper, 1989(j, aa, ab, ac); Anderson and Earl, 1993; Dick et al, 1995; Calderbank and McKenna, 1964; Roper and Elvira, 1996).

Potatoes exposed to pre-harvest desiccant applications of paraquat demonstrated decreases in residues by ~70% after peeling (Roper, 1989 (z); Alary et al, 1974).

Juice from pineapples exposed to exaggerated rates of paraquat (11 kg ac/ha) decreased by 25% from the raw fruit. Under normal label rates no residues would be expected in fruit juices (Roper, 1989(af)).

Residues in refined sugar would not be expected under GAP. Residues in malt derived from treated barley would be expected to decrease by 20 to 70% (Roper, 1989(ad, ae)).

Processing studies did show that paraquat would concentrate in the outer covering of cereal grains and oilseeds by 2 to 5 times. However, residues in flour would decrease by 70 to 90% (Roper, 1989(aa)).

5.13.1 Vegetable oil

Vegetable oils can be derived from a variety of sources: cottonseed; peanuts; other oilseeds; olives and pulses. Except for cotton seed which has a proposed MRL of 0.2 mg/kg, the remaining commodities have proposed MRLs at the LOQ (generally 0.05 mg/kg). Processing studies described above have indicated that even with residues of 0.2 mg/kg in the primary commodity, no residues above the LOQ were detected in oil. Therefore, an MRL can be established at the LOQ (0.05 mg/kg).

The recommended entry into the MRL Standard for edible vegetable oil is:

OR 0172 Vegetable oils, edible	*0.05 mg/kg

5.14 Residues in animal feed commodities

The current MRL for animal feed commodities is 500 mg/kg for primary feed commodities.

The critical use will be for pastures where the grazing WHP is 1 day (except for horses which is 7 days) and application rates are up to 0.6 kg ac/ha.

5.14.1 Animal feeds derived from grasses

In pre-emergence grass pasture trials from the US indicate that at Australian rates up to 0.6 kg ac/ha, no detectable residues in grass forage or hay would be expected. No residues are expected in cereal grain forage or fodder as the use pattern is solely a pre-emergent/pre-sowing one (Calderbank and McKenna, 1964; Roper, EM (1989(an, ao)). The hay-freezing use on some labels would be expected to be covered by the assessment for pastures grasses below.

Residues in forage in pasture grasses treated at 0.55 kg ac/ha (0.9x) ranged from 100 to 140 mg/kg dry weight (DW) at 1 day after application. Residues in grass hay ranged from 120 to 220 mg/kg dry matter (DM) at 1 day after application (Calderbank and Yuan, 1963; Calderbank and McKenna, 1964: Anon., n.d.(a); Reeve, 1970; Fletcher, 1972, Roper, 1989(ag, ah)).

No changes are required to the current MRL of 500 mg/kg for paraquat on Primary feed commodities to cover the cereal / grass pasture uses.

5.14.2 Legume animal feeds

Legume animal feeds include fodder from pulses, from legume vegetables and fodder from pasture legumes such as lucerne, vetch clover. The current Australian use pattern for pulses (including vetch) is 0.2 kg ac/ha with a 7 or 14 day WHP for livestock while the legume vegetable use is pre-emergent. The use pattern for pastures and lucerne is 0.6 kg ac/ha with a 1 day grazing WHP. Therefore, the highest residues for legume animal feeds are likely to come from pasture legumes.

The maximum residue in fodder or straw of pulses was 12 mg/kg following the Australian GAP (Roper, 1989(ak, al, am)).

Residues in lucerne fodder and forage at GAP ranged from 40 to 170 mg/kg DM (Anon., n.d.(b); Reeve, 1970; Anon., n.d.(e); Roper, 1989(aj); Coombe, 1990). Residues in clover fodder and forage ranged from 50 to 180 mg/kg (Roper, 1989(am)). Residues in birdsfoot trefoil fodder and forage ranged from 100 to 250 mg/kg (Roper, 1989(ao)).

No changes are required to the current MRL of 500 mg/kg for paraquat on primary feed commodities to cover the uses on legume animal feeds.

5.14.3 Cotton trash

No suitable data on cotton trash at the Australian label rates was presented, however processing data indicates that paraquat will concentrate in cotton trash by 3 to 190 times. Without cotton trash data relevant to the Australian use pattern, an appropriate MRL cannot be established for cotton trash.

In the absence of relevant data for cotton trash or fodder, the restraint of ‘DO NOT feed cotton fodder, stubble or trash to livestock’ is recommended for cotton uses. Cotton trash is not used as an animal feed due to unacceptable residue risks from multiple pesticides currently used in cotton. As noted in submissions, this is normally managed by a label statement prohibiting the feeding of cotton trash to animals, which is considered cotton industry best practice.

5.14.4 Almond hulls

Residues in almond hulls (from almonds collected from the tree) at 1 day after application at 1.1 kg ac/ha (1.4×) were <0.01 (3), 0.02 (2), 0.06 and 0.12 mg/kg (Anon., (1966). The OECD MRL calculator recommends an MRL of 0.2 mg/kg, the STMR is 0.02 mg/kg. An MRL of 0.2 mg/kg is recommended for paraquat on almond hulls in conjunction with a withholding period of “Not required when used as directed”.

5.14.5 Other animal feeds

Residues in minor animal feed commodities form no more than 20% of the diet livestock and will not influence animal MRLs due to the higher residues of paraquat in pastures, hay and fodder. Such animal feeds include citrus pulp, grape pomace, apple pomace and tomato pomace and the primary crops may be treated with pre-emergent or directed applications and should not result in residues in the raw commodity or animal feed. MRLs in Table 4 of the MRL standard are not considered necessary as residues above the LOQ are not expected.

5.15 Animal transfer studies and required animal commodity MRLs

Metabolism and animal residue studies indicate that paraquat is not fat-soluble. The WHP of 7 days for horses appear to be based upon toxic/irritant effects on oral mucous membranes of horses after consuming herbage freshly treated with paraquat rather than residue related reasons (Walley et al, 1966; Calderbank et al, 1968). This horse withholding period will not be reconsidered as part of this residues assessment.

5.15.1 Poultry

Metabolism studies indicate that there is little metabolism of paraquat in the hen (97–98% of radioactivity is the parent compound) and that elimination is entirely by the faecal route (at least 99% of radioactivity at 30 and 60 ppm). Radioactive labelling also indicated that egg residues were mainly the parent compound with most being found in the yolk and very little in the albumen. At 6 ppm in the diet, whole egg residues showed a plateau around 0.01 mg/kg, but at 30 ppm in the diet, no plateau effect occurred after 10 days with residues reaching 0.05/0.06 mg/kg. Highest tissue levels were 0.113 and 0.072 mg/kg in the kidney and liver respectively (Fletcher, 1974; Leary, 1974).

Two animal transfer studies in hens produced similar residue levels as seen in the metabolism studies. Plateaux in whole egg residues were seen at 0.01, 0.02 and 0.05 mg/kg with dietary feeding of 6, 13 and 30/36 ppm respectively. The whole egg residues did not accumulate and declined further when an untreated diet was fed. Tissue residues were less than 0.01 mg/kg when fed diets containing 1.8, 3.6,6, or 7.2 ppm paraquat. At a feeding rate of 13 ppm, tissue levels were less than 0.01 mg/kg with the exception of the kidney where residues of 0.05 and 0.06 mg/kg were found. At 30 ppm in the diet kidney residues were up to 0.14 mg/kg, liver residues were up to 0.1 mg/kg and muscle residues up to 0.05 mg/kg but all decreased to less than 0.05 mg/kg after a 7 day withdrawal period (Anon., 1976; Earl and Boseley, 1988(c)).

A typical poultry ration would contain up to 70% cereal grains, 10% animal protein and 20% vegetable protein. Pulses can be up to 25% of the ration but usually at the expense of some grain or vegetable protein. The only feed components of poultry diet that would have residues above the LOQ are cotton seed (0.2 mg/kg) and pulses (1 mg/kg). The 2004 JMPR reported residues of 0.02 mg/kg in cotton meal when residues in fuzzy seed were 0.18 mg/kg. A diet based on pulses as a worst case containing maximum residues of 1 mg/kg would only produce a diet containing 1 ppm of paraquat. More refined dietary burden calculations for poultry broilers and layers are presented in Table 15 and Table 16 below using the OECD Feed Calculator and the relevant High Residue (HR) or Supervised Trials Median Residue (STMR).

Table 15: Calculation of poultry broiler dietary burden of paraquat

Poultry Broiler – for MRLs							
Commodity	Codex Commodity Code[5]	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue Contribution (ppm)
Alfalfa forage	AL	170	HR	100	170		
Potato culls	VR	0.09	HR	20	0.45		
Bean seed	VD	0.21	STMR	88	0.24	70	0.17
Lupin seed	VD	0.21	STMR	88	0.24		
Pea seed	VD	0.21	STMR	90	0.23		
Sorghum, grain	GC	0.05	STMR	86	0.06	30	0.02
Corn, field grain	GC	0.05	STMR	88	0.06		
Cotton meal	SM	0.02	STMR	89	0.0		
Total						100	0.18

Table 16: Calculation of poultry layer dietary burden of paraquat

Poultry broiler – for MRLs							
Commodity	Codex Commodity Code	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue Contribution (ppm)
Trefoil forage	AL	250	HR	100	250		
Grass hay	AF/AS	220	HR	100	220		
Potato culls	VR	0.09	HR	20	0.45		
Bean seed	VD	0.21	STMR	88	0.24	70	0.17
Lupin seed	VD	0.21	STMR	88	0.24		
Pea seed	VD	0.21	STMR	90	0.23		
Sorghum, grain	GC	0.05	STMR	86	0.06	30	0.02

[5] https://www.apvma.gov.au/crop-groups

Poultry broiler – for MRLs							
Commodity	Codex Commodity Code	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue Contribution (ppm)
Corn, field grain	GC	0.05	STMR	88	0.06		
Cotton meal	SM	0.02	STMR	89	0.0		
Total						100	0.18

Current MRLs for poultry are *0.05 for meat and offal and *0.01 for eggs. Data from the animal transfer studies in poultry indicate that a dietary intake of 7.2 ppm or less would not produce residues in excess of the current MRLs for meat, offal or eggs. Therefore, the estimated dietary burdens for commodities that would be relevant to poultry feed of 0.18 ppm should not result in residues for poultry meat, offal or eggs exceeding current LOQ MRLs.

It is concluded that the following poultry commodity MRLs which are currently in the MRL standard remain appropriate:

PE 0112 Eggs	*0.01 mg/kg
PO 0111 Poultry, edible offal	*0.05 mg/kg
PM 0110 Poultry meat	*0.05 mg/kg

5.15.2 Pigs

The pig residue transfer study indicated that diets containing 150 ppm paraquat ion produced residues in offal at 0.4 mg/kg or less and residues in meat had a plateau at 0.1 mg/kg but dissipated to 0.04 and 0.02 mg/kg on continued dosing out to 30-36 days. There was no accumulation in pig tissues. A diet containing 50 ppm paraquat ion had offal residues less than 0.09 mg/kg and muscle residues of 0.02 mg/kg. Metabolism studies with single doses of paraquat at 50 ppm produced offal residues up to 0.5 mg/kg and meat residues up to 0.06 mg/kg. Feeding at 8 ppm found no detectable residues in tissues (Hemingway et al, 1975).

Typical Australian pig feed can contain up to 85% grain and up to 15% protein meals (mainly meat meal and soybean meal). Pig diets are therefore unlikely to contain any significant residues of paraquat.

5.15.3 Ruminants

Dietary burdens calculations for beef and dairy cattle using the OECD Feed Calculator are presented in Table 17 and Table 18 below.

Table 17: Calculation of beef cattle dietary burden of paraquat

Beef cattle – for MRLs							
Commodity	Codex Commodity Code	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue Contribution (ppm)
Trefoil forage	AL	250	HR	100	250	100	250
Grass hay	AF/AS	220	HR	100	220		
Clover forage	AL	180	HR	100	180		
Alfalfa forage	AL	170	HR	100	170		
Potato culls	VR	0.09	HR	20	0.5		
Sorghum grain	GC	0.05	STMR	86	0.1		
Barley grain	GC	0.05	STMR	88	0.1		
Total						100	250

Table 18: Calculation of dairy cattle dietary burden of paraquat

Dairy cattle – for MRLs							
Commodity	Codex Commodity Code	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue Contribution (ppm)
Trefoil forage	AL	170	HR	100	250.0	40	100
Grass hay	AF/AS	220	HR	100	220.0	60	132
Potato culls	VR	0.09	HR	20	0.45		
Sorghum grain	GC	0.05	STMR	86	0.06		
Total						100	232

Metabolism studies in the cow, goat, sheep and pig indicated that paraquat was not readily metabolised but was rapidly eliminated, mainly in the faeces with a very small amount in the urine (Toral and Kay, 1964; Sarfety, 1963). Highest tissue residues were generally seen in the kidney then liver then muscle. There was very little in the fat. Single oral dosing at 8 mg/kg to cows found 0.005 ppm in the milk with paraquat, monoquat and the monopyridone of paraquat all present at 0.01 ppm or less.

Dosing over 3 consecutive days found a maximum of 0.01 mg/kg in the milk, but chemical analysis did not detect any parent paraquat (limit of determination 0.005 mg/kg). Goats dosed over 7 days demonstrated increasing milk residues to a maximum of 0.009 mg/kg (Hendley et al, 1976(a)).

Five feeding trials with cattle were submitted. Three were trials where cattle grazed treated pasture and hence were exposed to decreasing residue intakes over time though initial residues were high (up to 1000 ppm). The pasture applications were at rates double the maximum label rate for pastures.

Feeding studies concentrations up to 100 ppm for 30 days and at feed concentrations up to 170 ppm for 95 days found milk residues to be 0.001 mg/kg or less, offal residues were 0.3 mg/kg or less and muscle residues were less than 0.03 mg/kg. Pasture trials did not detect paraquat in milk or muscle. Residues in offal were mainly seen in the kidney with the highest residue being 0.16 mg/kg. Residues up to 72 mg/kg were seen in the digestive tract but this was due to the presence of treated fodder (Sarfety, 1963; Edwards at al, 1974; Walley et al, 1966; Calderbank et al, 1966; Calderbank et al, 1968; Litchfield, 1969; Edwards, 1977; Anon., 1985).

Residue studies with pasture grasses and legumes have indicated that the maximum residue limit should be set at 500 mg/kg DM. The HR was 250 mg/kg (dw) in legume animal feeds (trefoil fodder and forage). This MRL will be set on a use pattern based on pasture spraying with subsequent grazing. Under this setting, the pasture residues would decrease with time as indicated in the pasture trials.

Current MRLs for meat (mammalian) are *0.05, for edible offal (mammalian) are 0.5 and for milks are *0.01 mg/kg. Data from the animal transfer studies indicate that a dietary intake of 460 to 1030 ppm as an initial pasture residue would not exceed current MRLs for milks. Meat and offal residues would not exceed the current MRLs under such a feeding regime. Data from the other animal transfer studies indicated that cattle can be fed diets containing up to 170 ppm paraquat ion on a daily basis without exceeding current MRLs. The submitted studies have indicated the depletion of residues once access to paraquat has ceased with no residues were observed in tissues after a depuration period of 12-13 days.

It is concluded that the following mammalian commodity MRLs which are currently in the MRL standard remain appropriate:

MO 0105 Edible offal (mammalian)	0.5 mg/kg
MM 0095 Meat (mammalian)	*0.05 mg/kg
ML 0106 Milks	*0.05 mg/kg

As residues in tissues will meet current MRLs without the requirement for a slaughter (clean feed) interval, the 3 day slaughter interval can be removed from the grazing WHP statement. A one day grazing withholding period remains appropriate for livestock other than horses.

In relation to the slaughter (clean feed) interval, it is noted that residues in kidney plateaued at higher levels than in tissue. The HR in kidney after feeding at 170 ppm was 0.24 mg/kg. The estimated residue in kidney from feeding at the dietary burden for beef cattle of 250 ppm is 0.35 mg/kg. Residues in kidney were <0.04 mg/kg after 12 days on clean feed, the first sampling point after initial feeding at 170 ppm. The estimated half-life in kidney is therefore ≤4.64 days. It would take ≤13 days for the estimated kidney residue of 0.35 mg/kg to decline to the Codex mammalian offal MRL of 0.05 mg/kg.

To prevent an undue risk to international trade, it is considered appropriate to conduct a contemporary assessment of an Export Slaughter Interval (ESI) noting MRLs for animal commodities are not established in the EU and Korea, and that the Codex Edible offal (mammalian) MRL is 0.05 mg/kg (see Section 4). The available data suggests that after 13 days on clean feed, paraquat residues in kidney should be below 0.05 mg/kg, which is the Codex MRL. A 13 day ESI is recommended to prevent an undue risk to international trade of mammalian offal.

The following label statements are appropriate:

> LIVESTOCK DESTINED FOR EXPORT MARKETS
>
> The grazing withholding period only applies to stock slaughtered for the domestic market. Some export markets apply different standards. To meet these standards, ensure that in addition to complying with the grazing withholding period, the export slaughter interval is observed before stock are sold or slaughtered.
>
> EXPORT SLAUGHTER INTERVAL (ESI) 13 DAYS
>
> Livestock that has grazed on or been fed treated crops should be placed on clean feed for 13 days prior to slaughter

5.16 Crop rotation

Studies undertaken with radiolabelled paraquat applied to soil at 1.3x (1.05 kg ac/ha) and 20x (14.3 – 14.7 kg ac/ha) maximum label rates in which wheat, lettuce and carrot were subsequently planted indicated that detectable residues would not present in the plant commodities of following crops (Vickers et al, 1990; Wilkinson, 1980). Consideration of MRL coverage for following or plant back intervals is not required from a residues perspective.

5.17 Spray drift for livestock areas

Paraquat labels indicate application should be by ground application only. Droplet sizes are often not specified, some labels indicate droplets in the medium diameter range should be used.

The Regulatory Acceptable Level (RAL) and the buffer zones for livestock areas for the protection of international trade are assessed and set by the Residues and Trade section of the APVMA.

It is noted that the risk through spray drift is only for offal and that appropriate offal MRLs are established in Japan, Taiwan and the USA. However, offal MRLs are not established in the EU or Korea and the Codex Edible offal (mammalian) MRL is at 0.05 mg/kg. In an available dairy cattle transfer study, feeding at 25 ppm gave a high residue of 0.13 mg/kg in kidney. The feeding level for residues in kidney to be at the Codex Edible offal (mammalian) MRL of 0.05 mg/kg is 9.62 ppm so the RAL for paraquat spray drift to livestock areas is established at 9.62 mg/kg.

The RAL for the combination of paraquat plus diquat in products containing both active constituents is adjusted for the combined total active applied but driven by paraquat (as the more sensitive endpoint), resulting in a RAL for the combined actives of 17.8 mg/kg.

5.18 Dietary risk assessment

The following health standards have been established in the APVMA ADI and ARfD lists, as of 18 December 2023 and by the JMPR (2003). The APVMA's conclusions following consideration of all information received during consultation on the proposed regulatory decisions published on 30 July 2024, is that the ADI and ARfD established at 0.004 mg/kg bw are appropriate.

Table 19: Health Standards established for paraquat

Compound	Dietary standard, mg/kg bw		No Observable Adverse Effect Level (NOAEL), mg/kg bw (study)	Uncertainty factor	Reference/ date set
Paraquat (as cation)	ADI	0.004	0.45 (1-year dog)	100	APVMA 27 June 2003
	ARfD	0.004	0.45 (1-year dog)	100	APVMA 27 June 2003
Paraquat (ion)	ADI	0.005	0.45 (1-year dog)	100	JMPR (2003)
	ARfD	0.006	0.55 (13-week dog)	100	JMPR (2003)

5.18.1 Chronic dietary exposure assessment

The chronic dietary exposure to paraquat is estimated by the National Estimated Daily Intake (NEDI) calculation encompassing all registered/temporary uses of the chemical and the mean daily dietary consumption data derived primarily from the 2011-12 National Nutritional and Physical Activity Survey. The NEDI calculation is made in accordance with WHO Guidelines (WHO, 2008) and is a conservative estimate of dietary exposure to chemical residues in food. The NEDI for paraquat is equivalent to <20% of the Australian ADI.

It is concluded that the chronic dietary exposure of paraquat is acceptable.

5.18.2 Acute dietary exposure assessment

The acute dietary exposure is estimated by the National Estimated Short Term Intake (NESTI) calculation. The NESTI calculations are made in accordance with the deterministic method used by the JMPR with 97.5th percentile food consumption data derived primarily from the 2011–12 National Nutritional and Physical Activity Survey. NESTI calculations are conservative estimates of short-term exposure (24 hour period) to chemical residues in food.

The highest acute dietary intake was estimated at <80% of the Australian ARfD for the uses supported by this residues and trade evaluation. It is concluded that the acute dietary exposure is acceptable.

It is noted that if residues in potatoes were at the current MRL of 0.2 mg/kg the acute dietary exposure for children would be equivalent to 171% of the ARfD. It is also noted that if an application timing of 14 days before digging was considered for potatoes then the scaled HR of 0.13 mg/kg would give an unacceptable acute dietary exposure for children (111% of the ARfD). The estimated acute exposure associated with the scaled HR of 0.09 mg/kg for the supported use (application 4-5 weeks before digging) is however acceptable (77% of the ARfD for children and 32% of ARfD for general population).

5.19 Trade

Table 20: Overseas MRLs established for major export commodities (December 2023)

Commodity	Australia	Codex[6]	EU[7]	Japan[8]	Korea[9]	Taiwan[10]	USA[11]
Residue definition	Paraquat cation	Paraquat cation	Paraquat	Paraquat	-	-	Calculated as the cation
Cereal grains	*0.05 (proposed) Current: 0.1 (maize) 10 (rice) 0.5 (rice, polished) *0.05 (other cereals)	0.03 (maize) 0.05 (maize flour) 0.05 (rice) 0.03 (sorghum)	*0.02 (barley, maize, oat, rye, wheat) 0.05 (rice)	0.1 (brown rice) 0.05 (wheat) 0.05 (barley) 0.05 (rye) 0.1 (corn)	0.05 (rice) 0.03 (corn)	0.03 (corn) 0.2 (rice) 0.03 (sorghum)	0.05 (barley) 0.1 (corn, field, grain) 0.05 (rice, grain) 1.1 (wheat grain)
Cotton seed	0.2 (current)	2	*0.02	0.2	2.0	-	3.5
Oilseed {except cotton seed}	*0.05 (current)	2 (sunflower seed)	*0.02	0.05 (rapeseeds)	-	-	2 (sunflower seed)
Pulses	1 (chickpeas, faba beans, field peas, lentils, lupins)	0.5 (pulses)	*0.02	0.05 (beans, dried) 0.05 (other legumes /	0.2 (soya bean)	0.5 (soya bean)	0.3 (lentil, seed) 0.3 (pea and bean, dried and

[6] Food and Agriculture Organisation of the United Nations (FAO), 2023. *Codex Alimentarius, International Food Standards,* FAO website, accessed December 2023.

[7] European Commission (EC), *EU Pesticides Database*, EC website, accessed December 2023.

[8] Japanese Food Chemistry Research Foundation (JFCRPF), 2023. *Table of MRLs for Agricultural Chemicals,* JFCRPF website, accessed December 2023.

[9] Ministry of Food and Drug Safety Korea, 2023. *MRLs in Pesticides*, accessed December 2023.

[10] Laws & Regulations Database of the Republic of China (Taiwan),2023. *Standards for Pesticide Residue Limits in Foods*, accessed December 2023.

[11] Electronic Code of Federal Regulations (eCFR), 2023. *USA Electronic Code of Federal Regulations,* eCFR website, accessed December 2023.

Commodity	Australia	Codex[6]	EU[7]	Japan[8]	Korea[9]	Taiwan[10]	USA[11]
	*0.05 (others)(proposed) 1 (current for all pulses)			pulses) 0.1 (soya bean)			shelled except soybean, guar bean) 0.7 (soya bean)
Sugar cane	*0.05 (current)	-	*0.02	0.3	-	-	0.5
Berries and other small fruits (grapes)	*0.01 (proposed) Current: *0.05 (Fruits, except olives)	0.01	*0.02 (grapes)	0.05		0.01 (grape)	0.05 (grape)
Citrus fruit	*0.01 (proposed) Current: *0.05 (Fruits, except olives)	0.02	*0.02	0.05	-	-	0.05
Pome fruit	*0.01 (proposed) Current: *0.05 (Fruits, except olives)	0.01	*0.02	0.05	-	0.01	0.05
Stone fruit	*0.01 (proposed) Current: *0.05 (Fruits, except olives)	0.01	*0.02	0.05	-	0.01 (cherry, nectarine, peach, plum, prune))	0.05
Edible offal (mammalian)	0.5 (current)	0.05	-	0.3 (cattle liver) 0.5 (cattle kidney)	-	0.5 (kidney) 0.05 (edible offal except kidney)	0.5 (cattle kidney) 0.05 (cattle meat by-products, except kidney)
Meat [mammalian]	*0.05 (current)	0.005	-	0.05 (cattle muscle) 0.05 (cattle fat)	-	0.05	0.05 (cattle meat) 0.05 (cattle fat)
Milks	*0.01 (current)	0.005	-	0.01	-	0.01	0.01

Export of treated produce containing finite (measurable) residues of paraquat may pose a risk to Australian trade in situations where (i) no residue tolerance (import tolerance) is established in the importing country or (ii) where residues in Australian produce are likely to exceed a residue tolerance (import tolerance) established in the importing country.

The MRL changes proposed as part of this review are in general new MRLs at the LOQ for analytical methods (cereal grains, oilseed (except cotton), pulses {except chickpeas, faba beans, field peas, lentils and lupins}) and various fruit crops). The risk to trade in these commodities is low.

For cottonseed and specified pulses (chickpeas, faba beans, field peas, lentils and lupins) MRLs will remain in place at the same levels. The cotton MRL at 0.2 mg/kg is lower than that established by Codex and the USA and at the same level as those established in Japan and Korea. The chickpea, faba bean, field pea, lentil and lupin MRLs at 1 mg/kg are higher than tolerances established overseas, however the risk is unchanged to that which has currently been managed. No changes have been recommended to the sugar cane MRL (at *0.05 mg/kg) with only the pre-planting use supported. The risk to trade in sugar is therefore reduced.

No changes have been proposed to the current animal commodity MRLs for paraquat. The meat and milk MRLs are at the LOQ, while the edible offal (mammalian) MRL is at the same level as those established for cattle kidney in Japan, Taiwan and the USA. However, MRLs for animal commodities are not established in the EU and Korea, and the Codex Edible offal (mammalian) MRL is 0.05 mg/kg. As finite residues may occur in mammalian offal as a result of the proposed use in pasture and hay, an Export Slaughter Interval (ESI) is recommended. The available data suggests that after 13 days on clean feed, paraquat residues should be below 0.05 mg/kg, which is the Codex MRL. A 13 day ESI is recommended to prevent an undue risk to international trade of mammalian offal.

Oaten hay is also a major export commodity, noting that an MRL of 500 mg/kg has been supported for paraquat on Primary feed commodities. An animal feed MRL of 5 mg/kg has been established for paraquat on grass in Japan. This risk to trade is unchanged. A response to the initial consultation was provided by AgriFutures Australia on behalf of the Australian Export Fodder Industry. The fodder industry supported the recommended label changes for paraquat to assist industry to meet market requirements. The fodder industry also supported the MRL recommendations made as part of the review evaluation.

For specified pulses (chickpeas, faba beans, field peas, lentils and lupins) and oaten hay, finite residues of paraquat are expected from the Australian uses. As the potential trade risk associated with paraquat residues expected in specified pulses (chickpeas, faba beans, field peas, lentils and lupins) and oaten hay have been managed by industry, and because international standards for paraquat have not significantly changed in recent years, it is currently considered that the trade risk associated with the uses of paraquat in pulses and oaten hay is not undue. However, as the Australian MRLs are higher than those set by Codex or major export destinations, it is recommended that the following Trade Advice statement should be added to the labels of products containing pre-harvest uses on cottonseed and specified pulses (chickpeas, faba beans, field peas, lentils and lupins) and the 'hay-freezing' use:

> EXPORT OF TREATED PRODUCE: Growers should note that maximum residue limits (MRLs) or import tolerances may not exist in all markets for [edible produce name] treated with [chemical product name]. If you are growing [edible produce name] for export, please check with [company name, industry body, etc.] for the latest information on MRLs and import tolerances before using [chemical product name].

At the request of participating industries, the National Residue Survey (NRS) submitted residue sampling data which demonstrates a high degree of export compliance with importing countries paraquat MRLs for cereals, pulses and oilseeds. The National Working Party on Grain Protection (NWPGP) indicated that it did not have any concerns with industry's ability to continue to manage the potential risks to international trade for any paraquat use pattern, including the pre-harvest uses of paraquat for spray topping treatment to reduce seed set of ryegrass in selected pulses (Broad bean, Chick-pea, Field pea, Lentil and Lupin).

5.20 Conclusions from the residues and trade assessment

The Residues and Trade section recommends that the APVMA should be satisfied that the continued approval of the use patterns as currently described would not pose an undue hazard to the safety of people consuming anything containing its residues, according to the safety criteria as defined by Section 5A nor an undue risk to international trade as described by Section 5C of the Schedule to the Code Act, with the following exceptions:

> Potato: There was sufficient residues data relevant to support an application timing of 7 or 14 days before digging, however, the scaled HR at 14 days (0.13 mg/kg) would give an unacceptable acute dietary exposure for children (111% of ARfD). Application to potatoes 14 days (or less) before digging therefore cannot be supported due to acute consumer safety concerns. It is therefore recommended that labels that currently have the '3 to 7 days before digging and after tops have died down' instruction must be changed to state that application must occur '4-5 weeks before digging'.
>
> Sugar cane: The over-the-top post-emergent application to sugar cane up the 3 to 4 leaf stage, which was not supported in the Proposed Regulatory Decision, can now be supported without any changes required to MRL of *0.05 mg/kg for paraquat on GS 0659 Sugar cane based on additional residue data submitted.

Expression of crop groups: The following crops were considered against the broad claims for orchards (including bananas) and vineyards and row crops, vegetables and market gardens:

- Orchards (including bananas) and vineyards:
  - Citrus, grapes, pome fruit, stone fruit, tree nuts, tropical fruit (edible peel), tropical fruit (inedible peel, except pineapple)
- Row crops, vegetables and market gardens:
  - Berries and other small fruit (except grapes) brassica vegetables, bulb vegetables, fruiting vegetables (cucurbits), fruiting vegetables (other than cucurbits), leafy vegetables, legume vegetables, pineapple, root and tuber vegetables; stalk and stem vegetables, herbs and spices

The directions for use tables on product labels should be amended to indicate the specified crops/crop groups as above for the orchards (including bananas) and vineyards, and row crops, vegetables and market gardens uses. The broad terms of 'orchards (including bananas) and vineyards' and 'row crops, vegetables and market gardens uses' should be removed from labels as they are not directly linked to contemporary APVMA crop group guidelines.

The following withholding periods and trade advice statements are supported by this evaluation:

- A 14-day harvest withholding period is recommended for the spray topping use on chickpeas, faba beans, field peas, lentils, lupins (some labels currently have 7 days, while others have 14 days)
- A 7-day harvest withholding period remains appropriate for the pre-harvest desiccation use on cotton

- In the absence of relevant data for cotton trash or fodder, the restraint of 'DO NOT feed cotton fodder, stubble or trash to livestock' is recommended for cotton uses.
- Recommended harvest withholding periods for all other uses are 'Not required when used as directed' for pre-emergent or pre-sowing applications (and for post emergent application in peanuts up to 7–8 leaf stage, potatoes no later than 25% emergence and potatoes at 4–5 weeks before digging) and for post-emergent directed applications

No changes to the intent of the current grazing withholding periods are required, however language changes are recommended based on the current Agricultural labelling code. The slaughter interval should be replaced with a 13-day ESI. The following label statements are recommended:

- LIVESTOCK: DO NOT GRAZE OR CUT FOR STOCK FOOD FOR 1 DAYS AFTER APPLICATION
- HORSES: DO NOT GRAZE OR CUT FOR STOCK FOOD FOR 7 DAYS AFTER APPLICATION
- LIVESTOCK DESTINED FOR EXPORT MARKETS

  The grazing withholding period only applies to stock slaughtered for the domestic market. Some export markets apply different standards. To meet these standards, ensure that in addition to complying with the grazing withholding period, the export slaughter interval is observed before stock are sold or slaughtered.

- EXPORT SLAUGHTER INTERVAL (ESI) 13 DAYS

  Livestock that has grazed on or been fed treated crops should be placed on clean feed for 13 days prior to slaughter

- The following Trade Advice statement should be added to the labels of products containing pre-harvest uses on cottonseed and specified pulses (chickpeas, faba beans, field peas, lentils and lupins) and the 'hay-freezing' use:

  EXPORT OF TREATED PRODUCE: *Growers should note that maximum residue limits (MRLs) or import tolerances may not exist in all markets for [edible produce name] treated with [chemical product name]. If you are growing [edible produce name] for export, please check with [company name, industry body, etc.] for the latest information on MRLs and import tolerances before using [chemical product name].*

The following amendments should be made to the Agricultural and Veterinary Chemicals (MRL Standard for Residues of Chemical Products) Instrument 2023, should all the uses supported in this Residues and Trade assessment of paraquat be supported by the APVMA chemical review:

Table 21: Amendments to Table 1 of the MRL Standard

Code	Commodity	Current MRL	Recommended MRL
FT 0026	Assorted tropical and sub-tropical fruits – edible peel	-	*0.05
FI 0030	Assorted tropical and sub-tropical fruits – inedible peel	-	*0.01
FB 0018	Berries and other small fruits	-	*0.01

Code	Commodity	Current MRL	Recommended MRL
VB 0040	Brassica (cole or cabbage) vegetables, head cabbages Flowerhead brassicas	-	*0.03
VD 0523	Broad bean (dry), [faba bean (dry)]	-	1
VA 0035	Bulb vegetables	-	*0.01
GC 0080	Cereal grains [except maize; rice]	*0.05	Delete
GC 0080	Cereal grains	-	*0.05
VD 0524	Chick-pea (dry)	-	1
FC 0001	Citrus fruits	-	*0.01
SO 0691	Cotton seed	0.2	0.2
OR 0691	Cotton seed oil, edible	0.05	Delete
MO 0105	Edible offal (Mammalian)	0.5	0.5
PE 0112	Eggs	*0.01	*0.01
VD 0561	Field pea (dry)	-	1
VC 0045	Fruiting vegetables, cucurbits	-	*0.03
VO 0050	Fruiting vegetables, other than cucurbits	-	*0.01
	Fruits [except olives]	*0.05	Delete
HH 0092	Herbs	-	*0.05
DH 1100	Hops, dry	0.2	*0.05
VL 0053	Leafy vegetables	-	*0.02
VP 0060	Legume vegetables	-	*0.05
VD 0533	Lentil (dry)	-	1
VD 0545	Lupin (dry)	-	1
GC 0645	Maize	0.1	Delete
MM 0095	Meat [mammalian]	*0.05	*0.05
ML 0106	Milks	*0.01	*0.01
SO 0088	Oilseed [except cotton seed; peanut]	*0.05	Delete

Code	Commodity	Current MRL	Recommended MRL
SO 0088	Oilseed {except cotton seed}	-	*0.05
FT 0305	Olives	1	Delete
SO 0697	Peanut	*0.01	Delete
SO 0703	Peanut, whole	*0.01	Delete
FP 0009	Pome fruits	-	*0.01
VR 0589	Potato	0.2	0.2
PO 0111	Poultry, edible offal of	*0.05	*0.05
PM 0110	Poultry meat	*0.05	*0.05
VD 0070	Pulses	1	Delete
VD 0070	Pulses {except broad bean (dry); Chick-pea (dry); Field pea (dry); lentil (dry); lupin (dry)}	-	*0.05
GC 0649	Rice	10	Delete
CM 1205	Rice, polished	0.5	Delete
VR 0075	Root and tuber vegetables {except Potato}	-	*0.01
HS 0093	Spices	-	*0.05
VS 0078	Stalk and stem vegetables	-	*0.05
FS 0012	Stone fruits	-	*0.01
GS 0659	Sugar cane	*0.05	*0.05
TN 0085	Tree nuts	*0.05	*0.05
	Vegetables [except potato; pulses]	*0.05	Delete
OR 0172	Vegetable oils, edible	-	*0.05

Table 22: Amendments to Table 4 of the MRL Standard

Code	Animal feed commodity	Current MRL	Recommended MRL
	Primary feed commodities	500	500
	Almond hulls	-	0.2

5.21 Consideration of combined risk assessment outcomes for paraquat

The APMVA's risk assessments for environmental exposure to paraquat based on currently approved uses indicate that many of the uses supported by the residues and trade assessment will not continue to be supported (see Appendix A). The uses that are supported by the combined APVMA risk assessment are presented in Table 23 and Table 24 below. These uses are within the application rate range indicated on currently approved labels.

Table 23: Paraquat (including paraquat plus amitrole) uses supported by human health, environment, and residues and trade risk assessments

Crop Use or Situation	Weeds controlled / Use	Application Method	Assessment outcome
Aid to cultivation; crop, pasture or fallow establishment	Wild oats at 2–5 leaf stage (autumn/winter) low rate	Boomspray	Supported up to 231 g ac/ha
Fallows	Barnyard grass, bladder ketmia, yellow vine (caltrop)	Optical spot spray technologies	Up to 770 g ac/ha (231 g ac/ha based on 30% area treated)
Firebreaks	Annual grasses and broadleaf weeds	Boomspray	Supported at 390-1020 g based on weight of evidence argument
	Knock down weed growth to eliminate fire hazard or assist firebreak burn.	Boomspray	
Non-agricultural situations (around sheds, roadways, paths)	Annual grasses and broadleaf weeds, columbus grass	Boomspray	
Peanuts (up to 7–8 leaf stage)	Annual ground cherry (2–3 leaf), apple-of-Peru (2–4 leaf), milkweed (2–3 leaf)	Boomspray	Supported up to 231 g ac/ha
	Bellvine (2–3 leaf), common morning glory (2 leaf)		
	Datura spp. (2–4 leaf)		
	Stagger weed (2–3 leaf), blue heliotrope (2–3 leaf), wandering jew (2–3 leaf), anoda weed (2–4 leaf)		
Rice	Post-sowing, pre-crop emergence annual grass and broadleaf weed control	Boomspray	Supported up to 231 g ac/ha
Spray topping to reduce seed set (field peas, lupins, lentils, chickpeas, faba beans)	Annual ryegrass	Boomspray	Supported up 200 g ac/ha

Table 24: Paraquat and diquat combination uses that are supported by human health, environment and residues and trade risk assessments

Crop	Weeds Controlled / Use	Application Method	Assessment outcome
Aid to cultivation (Southern Australia - full disturbance) Winter Canola, chickpeas, wheat, barley, oats, rye, triticale, field beans, field peas, lentils, linseed (Linola), lupins, vetch Spring/summer Fodder rape, pigeon peas, safflower, sorghum, soybeans, sunflower Pasture Clover grass, lucerne, medics	Seedling grasses: annual ryegrass (Lolium rigidum), barley grass (Hordeum spp.), brome grass (Bromus spp.), volunteer cereals, wild oats (Avena spp.) (2–3 leaf) Vulpia (Silver Grass, Sand Fescue) (Vulpia spp.) (2–3 leaf) Seedling Brassica Weeds Other Seedling Broadleaved Weeds Deadnettle (*Lamium amplexicaule*), Fumitory (*Fumitory* spp.), Melilotus (*Melilotus* spp.), Pimpernel (*Anagallis* spp.), Poppy (*Papaver* spp.), Saffron Thistle (*Carthmus lanatus*), Sheepweed (*Buglossoides arvensis*) Wireweed (*Polygonum aviculare*) Marshmallow (*Malva parviflora*) Volunteer Beans, Peas & Lupins	Boomspray	Supported up to 251 g/ha of combined active constituents (700 mL of product/ha)
Aid to cultivation (Southern Australia - fallow/minimum disturbance)	Seedling Grasses: Annual Ryegrass (*Lolium rigidum*), Barley Grass (*Hordeum* spp.), Brome Grass (*Bromus* spp.), Volunteer Cereals, Wild Oats (*Avena* spp.) Vulpia (Silver Grass, Sand Fescue) (*Vulpia* spp.) Seedling Grasses Sorghum (Sorghum bicolour), Stink Grass (*Eragrostis cilianensis*)	Boomspray	Supported up to 251 g/ha of combined active constituents (700 mL of product/ha)

Crop	Weeds Controlled / Use	Application Method	Assessment outcome
Aid to cultivation (Northern Australia - full disturbance)	Seedling Broadleaved Weeds Boggabri (*Amaranthus mitchellii*), Hexham Scent (*Melilotus indicus*), Wild Carrot (*Daucus glochidiatus*), Speedy Weed (*Flaveria australasica*)	Boomspray	Supported up to 251 g/ha of combined active constituents (700 mL of product/ha)
Market Gardens, nurseries, vegetable crops, potatoes, pre-emergence weed control	Most Annual Grasses and Broadleaved Weeds	Spot spray only	Supported up to 251 g acs/ha (max 40% field treated)
Public Service Areas, Rights-of-Way	Most Annual Grasses and Broadleaved Weeds	High volume or power sprayer, spot spray	Supported

5.21.1 Aid to cultivation; crop, pasture or fallow establishment (supported use: 231 g ac/ha for paraquat only or 251 g acs/ha for paraquat/diquat combined)

Crops included on product labels are: canola, chickpeas, cereals (wheat, barley, oats, rye, triticale, sorghum, maize, millet), cotton, field beans, field peas, lentils, linseed, lupins, fodder rape, mungbeans, navy beans, peanuts, pigeon peas, safflower, soybeans, sunflower, pasture (clover, grass, lucerne, medic), vetch. Other products indicate the use for crop, pasture or fallow establishment.

The Cereal grain MRL recommended earlier at the LOQ of *0.05 mg/kg would remain appropriate for the supported use as a cultivation aid at a maximum rate lower than currently registered.

For Pulses other than those with a spray topping use (see below) the MRL recommended earlier at the LOQ of *0.05 mg/kg would remain appropriate for the supported use as a cultivation aid at a maximum rate lower than currently registered.

The LOQ MRL at *0.05 mg/kg recommended for Oilseeds {except Cotton seed} would remain appropriate for the supported use as a cultivation aid at a maximum rate lower than currently registered. As the pre-harvest desiccation use on Cotton is not supported by the environmental assessment the higher Cotton MRL is not required so the MRL at *0.05 mg/kg can be for all oilseeds for the cultivation aid use. This MRL will also cover the supported use on peanuts below.

Although the environment risk assessment has not supported any of the specific uses of paraquat on sugarcane, the sugarcane MRL at *0.05 mg/kg can remain in place to cover the general use for crop, pasture or fallow establishment.

The supported harvest withholding period for these uses is “Not required when used as directed”. The supported grazing withholding period is discussed below.

The LOQ MRLs recommended above would also cover use on fallow by optical spot sprayers prior to planting a crop with only 30% of the area treated to a maximum rate of 231 g ac/ha.

5.21.2 Market Gardens and nurseries, vegetable crops and potatoes pre-emergent or early emergent weed control (supported at up to 251 g acs/ha for paraquat/diquat combined – spot spraying only)

A lower rate has been supported by the environment risk assessment but the APVMA have previously proposed LOQ MRLs for paraquat for various vegetables (except potatoes), herbs, spices and berries and other small fruits (except grapes).

It is recommended that these LOQ MRLs will continue to remain appropriate for the supported lower application rate (a separate MRL for potatoes is not required as the pre-harvest use on potatoes has not been supported).

5.21.3 Peanuts (supported use: 231 g ac/ha)

The supported use on peanuts from the environmental assessment was for application at up to the 7-8 leaf stage at 213 g ac/ha. The supported rate change is within 25% of the maximum registered rate (250 g ac/ha). The previous recommendations with respect to peanuts remain appropriate and the use will be covered by the Oilseeds MRL recommended above at *0.05 mg/kg.

A harvest withholding period statement of 'NOT required when used as directed' is appropriate as the use is only permitted up to the 7-8 leaf stage. The supported grazing withholding period is discussed below.

5.21.4 Spray topping to reduce seed set (Field peas, Lupins, Lentils, Chickpeas, Faba Beans. Supported use: 200 g ac/ha)

The use pattern for spray topping to control seed set of annual rye grass in field peas, lupins, lentils, chickpeas and faba beans, supported by the environmental assessment, at the maximum rate of 200 g ac/ha. Australian trials with chickpeas, field peas and lupins at 200 and 400 g ac/ha found residues in seed were up to 0.41 mg/kg at the label rate and up to 0.54 mg/kg at double the maximum application rate following a 14 day PHI. Residues at 14-15 day PHI (or later if higher) following one application at 200 g ac/ha were 0.05, 0.1, 0.31 and 0.41 mg/kg. Given the limited dataset that relies on residues remaining within the MRL for the higher application rates, the previously recommended MRLs in relation to pulses will remain appropriate for the supported use at the lower rate:

The recommended entries into the MRL Standard for pulses are as follows noting that the most common LOQ in the available pulse trials was 0.05 mg/kg:

VD 0070 Pulses {except Broad bean (dry); Chick-pea (dry); Field pea (dry); Lentil (dry); Lupin (dry)}	*0.05 mg/kg
VD 0523 Broad bean (dry) [faba bean (dry)]	1 mg/kg
VD 0524 Chick-pea (dry)	1 mg/kg

VD 0561 Field pea (dry)	1 mg/kg
VD 0533 Lentil (dry)	1 mg/kg
VD 0545 Lupin (dry)	1 mg/kg

As before, the data supports a 14 day withholding period for the spray toping use at 200 g ac/ha for chickpeas, faba beans, field peas, lentils and lupins. For labels with a 7 day withholding period for this use pattern, the withholding period should be changed to 14 days as there was insufficient residues data addressing a 7 day withholding period. For other pulses the supported withholding period is “Not required when used as directed” as the use would be pre-emergent or directed to inter row weeds. The supported grazing withholding period is discussed below.

5.21.5 Rice

The use on rice supported by the environmental risk assessment was the maximum post-sowing, pre-crop emergence use on the current labels of 200 g ac/ha. A use on rice pre-crop emergence at 200 g ac/ha as registered should not require any changes to the earlier recommended Cereal grains MRL at the LOQ at *0.05 mg/kg.

A harvest withholding period statement of ‘NOT required when used as directed’ is appropriate for rice as the use is pre-sowing or post sowing / pre-crop emergence. The supported grazing withholding period is discussed below.

5.21.6 Required animal commodity MRLs

In pre-emergence grass pasture, trials from the US indicate that at current Australian rates up to 600 g ac/ha, no detectable residues in grass forage or hay would be expected. No finite residues are expected in cereal grain forage or fodder as the use pattern is solely a pre-emergent/pre-sowing one. A similar outcome is expected for oilseeds. The maximum residue in fodder or straw of pulses was 12 mg/kg following the Australian GAP. Residue data for peanut hay which can form 60% of the diet for beef and dairy cattle are not available. Highest residues in lucerne and clover forage and fodder after application at 600 g ac/ha were similar at 170 – 180 mg/kg (dry weight), although higher residues were observed in birdsfoot trefoil. Extrapolating the lucerne and clover data and scaling to the maximum application rate for peanuts of 213 g ac/ha the estimated HR in peanut forage and fodder is 63.9 mg/kg (dry weight).

The paraquat Primary Feed Commodities MRL at 500 mg/kg can be reduced to 100 mg/kg should the only supported use in animal feeds apart from pre-emergent application, be for post emergent treatment of peanuts or for spray-topping selected pulse crops.

The worst-case animal feeding burden (assuming 100% of the diet of mammalian livestock was from peanut forage/fodder) is 64 ppm. In available animal transfer studies, feeding at 80 ppm gave a HR in kidney of 0.31 mg/kg, noting that residues in kidney plateaued at higher doses (so the MRLs would also be appropriate for higher dietary burdens). It is concluded that the following mammalian commodity MRLs which are currently in the MRL standard remain appropriate:

MO 0105 Edible offal (mammalian)	0.5 mg/kg

MM 0095 Meat (mammalian) *0.05 mg/kg

ML 0106 Milks *0.05 mg/kg

The following label statements are recommended:

LIVESTOCK: DO NOT GRAZE OR CUT FOR STOCK FOOD FOR 1 DAYS AFTER APPLICATION.

HORSES: DO NOT GRAZE OR CUT FOR STOCK FOOD FOR 7 DAYS AFTER APPLICATION.

LIVESTOCK DESTINED FOR EXPORT MARKETS

The grazing withholding period only applies to stock slaughtered for the domestic market. Some export markets apply different standards. To meet these standards, ensure that in addition to complying with the grazing withholding period, the export slaughter interval is observed before stock are sold or slaughtered.

EXPORT SLAUGHTER INTERVAL (ESI) 13 DAYS

Livestock that has grazed on or been fed treated crops should be placed on clean feed for 13 days prior to slaughter

The poultry commodity MRLs for paraquat at the LOQ can remain in place to indicate that residues should not occur in poultry commodities due to the supported uses.

All other MRLs for paraquat can be deleted as no other uses are supported.

5.21.7 Trade

For specified pulses (chickpeas, faba beans, field peas, lentils and lupins) MRLs will remain in place at the same levels. The chickpeas, faba beans, field peas, lentils and lupins MRLs at 1 mg/kg are higher than tolerances established overseas, however the risk is unchanged to that which has currently been managed. The National Working Party on Grain Protection (NWPGP) indicated that it did not have any concerns with industry's ability to continue to manage the potential risks to international trade for pre-harvest uses of paraquat for spray topping treatment to reduce seed set of ryegrass in selected pulses (Broad bean, Chick-pea, Field pea, Lentil and Lupin).

For pulses (other than those specified above), cereals, and oilseeds MRLs have been recommended at the analytical method LOQ as finite residues are not expected to occur. The risk to trade in these commodities should be low.

The recommended ESI of 13 days will ensure there are no detectable residues in any animal commodities from livestock allowed to graze treated crops.

5.22 Revised dietary exposure assessment

5.22.1 Chronic dietary exposure assessment

The chronic dietary exposure to paraquat is estimated by the National Estimated Daily Intake (NEDI) calculation encompassing all registered/temporary uses of the chemical and the mean daily dietary consumption data derived primarily from the 2011-12 National Nutritional and Physical Activity Survey. The NEDI calculation is made in accordance with WHO Guidelines and is a conservative estimate of dietary exposure to chemical residues in food. The NEDI for paraquat is equivalent to <15% of the Australian ADI, for the uses proposed to be supported by the APVMA chemical review. It is concluded that the chronic dietary exposure to paraquat is acceptable.

5.22.2 Acute dietary exposure assessment

The acute dietary exposure is estimated by the National Estimated Short Term Intake (NESTI) calculation. The NESTI calculations are made in accordance with the deterministic method used by the JMPR with 97.5th percentile food consumption data derived primarily from the 2011-12 National Nutritional and Physical Activity Survey. NESTI calculations are conservative estimates of short-term exposure (24 hour period) to chemical residues in food.

The highest acute dietary intake was estimated at <50% of the Australian ARfD for the uses proposed to be supported by the APVMA chemical review. It is concluded that the acute dietary exposure to paraquat is acceptable.

5.23 Revised MRL recommendations

The following amendments should be made to the Agricultural and Veterinary Chemicals (MRL Standard for Residues of Chemical Products) Instrument 2023, at the end of any phase out period, to reflect uses which remain at the completion of the reconsideration.

Table 25: Amendments to Table 1 of the MRL Standard

Code	Commodity	Current MRL	Recommended MRL
FB 0018	Berries and other small fruits {except grapes}	-	*0.01
VB 0040	Brassica (cole or cabbage) vegetables, Head cabbages, Flowerhead brassicas	-	*0.03
VD 0523	Broad bean (dry) [faba bean (dry)]	-	1
VA 0035	Bulb vegetables	-	*0.01
GC 0080	Cereal grains [except maize; rice]	*0.05	Delete
GC 0080	Cereal grains	-	*0.05
VD 0524	Chick-pea (dry)	-	1

Code	Commodity	Current MRL	Recommended MRL
SO 0691	Cotton seed	0.2	Delete
OR 0691	Cotton seed oil, edible	0.05	Delete
MO 0105	Edible offal (Mammalian)	0.5	0.5
PE 0112	Eggs	*0.01	*0.01
VD 0561	Field pea (dry)	-	1
VC 0045	Fruiting vegetables, cucurbits	-	*0.03
VO 0050	Fruiting vegetables, other than cucurbits	-	*0.01
	Fruits [except olives]	*0.05	Delete
HH 0092	Herbs	-	*0.05
DH 1100	Hops, dry	0.2	Delete
VL 0053	Leafy vegetables	-	*0.02
VP 0060	Legume vegetables	-	*0.05
VD 0533	Lentil (dry)	-	1
VD 0545	Lupin (dry)	-	1
GC 0645	Maize	0.1	Delete
MM 0095	Meat [mammalian]	*0.05	*0.05
ML 0106	Milks	*0.01	*0.01
SO 0088	Oilseed [except cotton seed; peanut]	*0.05	Delete
SO 0088	Oilseed	-	*0.05
FT 0305	Olives	1	Delete
SO 0697	Peanut	*0.01	Delete
SO 0703	Peanut, whole	*0.01	Delete
VR 0589	Potato	0.2	Delete
PO 0111	Poultry, Edible offal of	*0.05	*0.05
PM 0110	Poultry meat	*0.05	*0.05
VD 0070	Pulses	1	Delete

Code	Commodity	Current MRL	Recommended MRL
VD 0070	Pulses {except Broad bean (dry); Chick-pea (dry); Field pea (dry); Lentil (dry); Lupin (dry)}	-	*0.05
GC 0649	Rice	10	Delete
CM 1205	Rice, polished	0.5	Delete
VR 0075	Root and tuber vegetables	-	*0.01
HH 0093	Spices	-	*0.05
VS 0078	Stalk and stem vegetables	-	*0.05
GS 0659	Sugar cane	*0.05	*0.05
TN 0085	Tree nuts	*0.05	Delete
	Vegetables [except Potato; Pulses]	*0.05	Delete
OR 0172	Vegetable oils, edible	-	*0.05

Table 26: Amendments to Table 4 of the MRL Standard

Code	Animal feed commodity	Current MRL	Recommended MRL
	Primary feed commodities	500	100

6 Environmental safety

6.1 Assessment scenarios

Paraquat products are registered for general weed control in a broad range of situations at rates ranging from 100 g ac/ha to 2250 g ac/ha. Most applications in crops are before planting or crop emergence (i.e. bare soil); however, applications can also occur at later crop stages and as directed sprays or inter-row treatments.

There is one diquat and paraquat combination product that is registered as a pre-harvest desiccant in cotton at a paraquat rate of up to 216 g ac/ha. There are also diquat and paraquat combination products that are registered for general weed control at paraquat rates up to 432 g ac/ha in a broad range of situations, including crops, pasture, forestry, public service areas, and rights of way. Spot spray application is also approved in tropical fruit orchards up to 32.4 g ac/100L (each application is equivalent to 324 g ac/ha assuming a spray volume of 1000 L/ha).

There are also 4 amitrole and paraquat combination products that are registered for general weed control at paraquat rates up to 1680 g ac/ha in fallow (including aid to cultivation), 850 g ac/ha in industrial vegetation management (firebreaks, sheds, roadways, paths), 600 g ac/ha in crops (orchards, vineyards, potatoes), and 300 g ac/ha in pasture (including spray topping and hay freezing).

The initial assessment addresses the risks of paraquat only, for all relevant uses. Risks of the combination of paraquat and diquat have been assessed separately for relevant uses. Risks from the combination of paraquat and amitrole have not been considered, noting that amitrole is not under reconsideration.

The environmental risk assessment scenarios considered in this assessment are summarised in the table below. Environmental risks were determined according to contemporary methodology outlined in the APVMA Risk Assessment Manual – Environment: https://apvma.gov.au/node/46416. All endpoints are expressed in terms of the paraquat cation as the active constituent.

Table 27: Paraquat – Environmental risk assessment scenarios

Category[12]	Situation	Risk assessment scenario
General weed control	Fallow	1× 150–1505 g ac/ha
	Fallow (optical spot spraying)	1× 750-2250 g ac/ha
	Non-agricultural situations, around sheds, roadways, paths, firebreaks	1× 390–1140 g ac/ha
	Orchards, vineyards	1× 280–810 g ac/ha
	Bananas	1× 175–1120 g ac/ha
	Potatoes	1× 300–720 g ac/ha
	Pasture[13]	1× 100–600 g ac/ha

[12] For products containing only paraquat categorisation is based on the broad use type. For mixed active products the categories group use situations associated with specific combinations of actives (irrespective of the broader use type)

[13] Includes spray topping to prevent ryegrass toxicity

Category[12]	Situation	Risk assessment scenario
	Lucerne, market gardens, row crops, vegetables	1× 300–600 g ac/ha
	Hops, sugarcane	1× 300–420 g ac/ha
	Rice	1× 200–420 g ac/ha
	Peanuts	1× 100–250 g ac/ha
	Spray topping in pulses	1× 100–200 g ac/ha
Combination products containing diquat	Cotton desiccation	1× 162–216 g ac/ha
	Spray topping in grasses	1× 108–203 g ac/ha
	Pasture	1× 162-432 g ac/ha
	Public service areas, rights of way, market gardens, nurseries, potatoes, vegetables	1× 324–432 g ac/ha
	Rice	1× 216–432 g ac/ha
	Vineyards	1× 324–432 g ac/ha
	Forests, orchards, plantations, duboisia, tea trees, bananas	1× 276–432 g ac/ha
	Fallow (minimal disturbance)	2× 162–432 g ac/ha 7-day retreatment interval
	Fallow (minimal disturbance)	1× 135–432 g ac/ha
	Fallow (full disturbance), lucerne	1× 81–324 g ac/ha
	Spot application in avocado, custard apples, lychees, mangos[14]	2× 162–324 g ac/ha 14-day retreatment interval
	Sugarcane	1× 162–432 g ac/ha
Combination products containing amitrole	Fallow	1× 112–600 g ac/ha
	Fallow (optical spot spraying)	1× 500–1680 g ac/ha
	Non-agricultural situations, around sheds, roadways, paths, firebreaks	1× 300–850 g ac/ha
	Orchards, vineyards	1× 300–600 g ac/ha
	Potatoes	1× 525 g ac/ha
	Pasture, including hay freezing and spray topping	1× 75–300 g ac/ha

6.2 Fate and behaviour in the environment

Paraquat's behaviour in soil has been well studied – see, e.g., reviews by Sartori & Vidrio (2018) and Roberts et al (2002) for a more expansive discussion of the available literature. Paraquat is very persistent and non-mobile in soil with low risk of leaching to groundwater. However, the behaviour of paraquat once it exceeds the absorption capacity of soil is less certain. For soils with ≤10% clay content, for which the absorption capacity is likely to be relatively low, the first (1.0th) and 10th percentile K_d values are 1100 and 2250 mL/g, respectively.

[14] Assuming a maximum of 40% of an orchard is treated, each application is equivalent to 130 g ac/ha across the entire orchard

A reliable definitive DT_{50} value for degradation in soil is not available. Therefore, the default DT_{50} for persistent substances (1000 days) is used for risk assessment; this will underestimate the persistence of strongly bound residues but is considered reasonably conservative for residues that are biologically available.

In aquatic systems, paraquat is highly soluble, but partitions rapidly to the sediment where it is strongly sorbs and is very persistent. Therefore, as for soil, the default DT_{50} of 1000 days for persistent substances is used for sediment. The maximum directly measured K_d from the dataset for soil (i.e. 50000 mL/g) is proposed as a conservative estimate for predicting sediment concentrations of paraquat – this is not reflective of any particular assumption about the sediment, but is simply a conservative value to ensure the model predicts that paraquat is largely associated with the sediment. Based on the behaviour of paraquat in chironomid toxicity tests (Hamer & Ashwell 1997), it is considered reasonably conservative to assume a DT_{50} of 7.0 days for dissipation from the water phase.

Paraquat has a reported vapour pressure of 5.3 10^{-4} (25°C) (Markell A, 2023) and is considered unlikely to be subject to long-range atmospheric transport.

Available residue data indicate paraquat dissipates more rapidly in insects than assumed by default for animal food items. The most conservative reliable DT_{50} of 4.6 days is used for predicting paraquat concentrations in insects.

The key regulatory endpoints for the environmental exposure assessment are summarised in Table 28. A full listing of endpoints is provided in Appendix B.

Table 28: Paraquat – Key regulatory endpoints for exposure assessment

Compartment	Value		Reference
Animal food items	Foliage: Seeds:	DT_{50} 10 d DT_{50} 10 d	Default
	Insects:	DT_{50} 4.6 d	Bakker 2005a, 2005b
Soil	DT_{50} 1000 d		Default for persistent substances, for residues in solution
	DT_{50} 20-60 years		Estimate based on Dyson & Chapman (1995), for residues bound to soil
	Sands:	1.0^{th} percentile K_d 1100 mL/g 10^{th} percentile K_d 2250 mL/g K_f 17.9, 1/n 0.41	Robbins et al. 1988, Dyson et al. 1994
			Amondham et al. 2006
Water	DT_{50} 7.0 d		Long et al, 1996, Hamer & Ashwell 1997
Sediment	DT_{50} 1000 d		Default for persistent substances
	K_p 50000 mL/g		Robbins et al, 1988
Air	DT_{50} 6.0 h		Hayes 2006

6.3 Effects on non-target species

Paraquat has high toxicity to mammals (lowest LD_{50} 22 mg ac/kg bw, *Cavia porcellus*) and birds (lowest LD_{50} 27 mg ac/kg bw, *Taeniopygia guttata*). Therefore, the following protection statement is recommended on paraquat product labels (followed by an appropriate risk management statement).

> Toxic to birds and native mammals.

Following long-term dietary exposure, mammals exhibit 17–43% mortality at 7.5 mg ac/kg bw/d (NOAEL 3.8 mg ac/kg bw/d), which is considered the ecologically relevant endpoint from the source study. An additional study is available where 24-37% mortality was observed at 14 mg ac/kg bw/d (NOAEL 7.2 mg ac/kg bw/d). Given the level of mortality observed at 7.5 mg ac/kg bw/d, the lower of the 2 NOAEL values is considered the relevant value for risk assessment.

For birds, reproductive toxicity has been tested in the mallard (*Anas platyrhynchos*), with an eighteen-week exposure period (10 weeks prior to full egg production and 8 weeks during full egg production). Biologically relevant reductions in eggs laid and numbers of viable/live embryos were observed at doses as low as 9.1 mg ac/kg bw/d (NOAEL 2.7 mg ac/kg bw/d).

Paraquat has moderate toxicity to fish (lowest LC_{50} 4.7 mg ac/L, *Pimephales promelas*) and aquatic invertebrates (lowest LC_{50} 0.23 mg ac/L, *Americamysis bahia*), and it has high toxicity to algae (lowest ErC_{50} 0.00034 mg ac/L, *Navicula pelliculosa*) and aquatic plants (EC_{50} 0.015 mg ac/L, *Lemna gibba*). Therefore, the following protection statement is recommended on paraquat product labels.

> Very toxic to aquatic life. DO NOT contaminate wetlands or watercourses with this product or used containers.

Reduced growth of fish was observed at concentrations as low as 1.5 mg ac/L (NOEC 0.74 mg ac/L, *Pimephales promelas*), whilst reduced survival and reproduction was observed in aquatic invertebrates at concentrations as low as 0.076 mg ac/L (NOEC 0.038 mg ac/L, *Americamysis bahia*).

Paraquat has moderate toxicity to freshwater amphipods (LC_{50} 39 mg ac/kg dry sediment, *Hyalella azteca*). It is noted that the clay content of the test sediment was relatively low (1%). Low toxicity was observed in midges (LC_{50} >100 mg ac/kg dry sediment, *Chironomus dilutus*) and marine amphipods (LC_{50} >100 mg ac/kg dry sediment, *Leptocheirus plumulosus*), noting the clay content in the test sediments ranged 17–25%. Following long-term exposure of midges, no significant adverse effects were observed at the highest tested concentrations in both water-dosed (NOEC 0.38 mg ac/L, *Chironomus riparius*) or sediment-dosed (NOEC 68 mg ac/kg dry sediment, *C. riparius*) test systems with 14-20% clay content in the sediments.

Noting that primary producers, such as algae, are most sensitive to paraquat, an SSD analysis was performed on the toxicity data (EC_{50} values) obtained in the absence of sediment. Paraquat dissipates quickly from the water column under natural conditions due to rapid adsorption to sediment and suspended particulates; therefore, the endpoints were adjusted to account for the expected dissipation under natural conditions (Table 29).

Given the uncertainties regarding the endpoints used in the SSD and the wide confidence intervals around the HC_5, an assessment factor of 3 is recommended[15]. The RAL for primary producers is therefore 0.00015 mg ac/L (HC_5 0.00045 mg ac/L and assessment factor of 3).

Paraquat has moderate toxicity to bees by contact exposure (lowest LD_{50} 16 µg ac/bee, *Apis mellifera*) and moderate toxicity by oral exposure (lowest LD_{50} 13 µg ac/bee, *Apis mellifera*).

In Tier 1 (glass plate) laboratory tests on the toxicity of an SL formulation of paraquat to the indicator species of predatory arthropods (predatory mite *Typhlodromus pyri*) the LR_{50} value is 1.9 g ac/ha. Exposure under Tier 2 (natural substrate) conditions did not greatly influence toxicity to the predatory mite, LR_{50} 8.2 g ac/ha (*Typhlodromus pyri*). Soil dwelling arthropods such as carabid beetles, spiders and rove beetles were unaffected at field relevant rates.

Paraquat has low toxicity to soil macro-organisms such as earthworms (LC_{50} >1000 mg ac/kg dry soil, *Eisenia fetida*). It is noted that the available acute toxicity test was conducted in artificial soil containing 20% kaolinite clay, as such it may not represent a realistic worst-case exposure system (i.e. compared to soils with lower capacity to adsorb and deactivate paraquat). However, the test was conducted at a rate exceeding the soil's expected strong adsorption capacity - wheat bioassay (SAC-WB 230-260 mg ac/kg dry soil), as measured for an artificial soil with the same composition as in the acute toxicity test. This implies that it is reasonable to conclude there would have been paraquat in excess of the SAC-WB in the acute toxicity test. There are no laboratory studies investigating long-term effects of paraquat in soil dwelling macro-organisms or micro-organisms.

Effects on soil macro-organisms and micro-organisms have been investigated in long-term field studies. Adverse effects on earthworms and soil micro-arthropods were observed at soil concentrations equivalent to 110 and 400% of the soils SAC (120 mg ac/kg dry soil). No adverse effects on soil micro-organisms were observed at soil concentrations as high as 400% of a soils SAC (120 mg ac/kg dry soil).

Paraquat has low toxicity to non-target terrestrial plants following pre-emergent exposure to soil residues under laboratory conditions (lowest definitive ER_{25} 712 g ac/ha, *Avena sativa*). However, because paraquat is a non-selective contact herbicide, post-emergent foliar exposure is of greatest concern. Under laboratory conditions, rough cocklebur was the most sensitive species following foliar exposure (ER_{50} 25 g ac/ha, *Xanthium strumarium*). An SSD analysis was performed on the post-emergent ER_{50} values for 12 non-target terrestrial plant species. An HR_5 of 31 g ac/ha was derived (Table 30), which is higher than the lowest ER_{50} value. As such the lower limit HR_5 of 11 g ac/ha was selected as the RAL for the protection of vegetation areas.

In terms of endocrine disrupting properties, results in non-mammalian species are either equivocal or negative. No targeted studies were available to mechanistically understand the reproductive toxicity to non-mammalian species; therefore, it is not possible to assess whether any observed effects were endocrine-mediated. Therefore, no firm conclusion can be drawn regarding endocrine effects of paraquat based on the available information in non-mammalian species.

[15] Consistent with EFSA (2013)

The regulatory acceptable levels (RALs) for the environmental risk assessment are provided in Table 31. The RAL values for the spray drift assessment are 0.15 µg ac/L for the protection of natural aquatic areas, 2667 g ac/ha for the protection of pollinator areas, and 11 g ac/ha for the protection of vegetation areas.

Table 29: Paraquat – Toxicity endpoints for primary producers used in SSD analysis

Species	Exposure days	Measured EC_{50}	Adjusted EC_{50}	Notes
Navicula pelliculosa	4	0.00034 mg ac/L	0.00041 mg ac/L	
Anabaena flos-aquae	5	0.0078 mg ac/L	0.0099 mg ac/L	
Lemna minor	7	0.015 mg ac/L	0.021 mg ac/L	
Chlamydomonas reinhardtii	3	0.045 mg ac/L	0.052 mg ac/L	(geomean of 2 studies)
Raphidocelis subcapitata	4	0.22 mg ac/L	0.27 mg ac/L	(geomean of 4 studies)
Lemna gibba	7/14*	0.038 mg ac/L	0.061 mg ac/L	(geomean of 2 studies)
Chlorella vulgaris	4	0.53 mg ac/L	0.64 mg ac/L	
Skeletonema costatum	4	5.9 mg ac/L	7.1 mg ac/L	
	HC_5	0.00035 mg ac/L (95% CI 0.000002-0.013)	0.00045 mg ac/L (95% CI 0.000002-0.018)	Model average result[16] based on gamma, log-gumbel, log-logistic, log-normal, log-normal_log-normal, and Weibull distributions (8 species)

Endpoints from Table B10 in Appendix B have been adjusted to account for rapid dissipation from the water column under natural conditions (adjusted EC_{50} = measured EC_{50} / (1 - EXP (exposure days * (-ln(2)/DT_{50} 7.0 days))) * (exposure days * ln(2)/DT_{50} 7.0 days)

*7d E_rC_{50} 0.031 and 14d E_rC_{50} 0.047 mg ac/L

Table 30: Paraquat – Post-emergent toxicity endpoints for non-target terrestrial plants used in SSD analysis

Species	ER_{50}	Notes
Xanthium strumarium	25 g ac/ha	
Lolium perenne	35 g ac/ha	
Beta vulgaris	68 g ac/ha	
Avena sativa	108 g ac/ha	
Abutilon theophrasti	135 g ac/ha	
Allium cepa	136 g ac/ha	
Brassica napus	161 g ac/ha	(geomean of 2 studies)
Lycopersicon esculentum	188 g ac/ha	
Ipomoea hederacea	201 g ac/ha	
Zea mays	207 g ac/ha	(geomean of 2 studies)
Cucumis sativa	267 g ac/ha	
Glycine max	476 g ac/ha	(geomean of 2 studies)
Raphanus sativus	—	
HR_5	31 g ac/ha (95% CI 11-75)	Model average result[17] based on gamma, log-gumbel, log-logistic, log-normal, log-normal_log-normal, and Weibull distributions

[16] Calculated using Shinyssdtools (Version 0.4.0) (Dalgarno 2021; https://bcgov-env.shinyapps.io/ssdtools/)

[17] Calculated using Shinyssdtools (Version 0.4.0) (Dalgarno 2021; https://bcgov-env.shinyapps.io/ssdtools/)

Table 31: Paraquat – Regulatory acceptable levels for non-target species

Group	Exposure	Endpoint	AF	RAL	Reference
Mammals	Acute	LD_{50} 61 mg ac/kg bw	10	6.1 mg ac/kg bw	Duerden 1994, Farnworth et al, 1993, Fletcher 1967, Heylings & Farnworth 1992, Kimbrough & Gaines 1970, Murray & Gibson 1974
	Chronic	NOAEL 3.8 mg ac/kg bw/d	1	3.8 mg ac/kg bw/d	Lindsay 1982a,1982b
Birds	Acute	LD_{50} 57 mg ac/kg bw	10	5.7 mg ac/kg bw	Fink et al, 1979, Hubbard et al, 2014, Johnson 1998
	Chronic	NOEL 2.7 mg ac/kg bw/d	1	2.7 mg ac/kg bw/d	Fink et al, 1982(a)
Aquatic species	Chronic	HC_5 0.45 µg ac/L*	3	0.15 µg ac/L	Baltazar et al, 2014, Cheloni & Slaveykova 2021, Jamers & de Coen 2010, Mohammad et al, 2010, Scheerbaum 2007b, Smyth et al 1990(a), 1990b, Smyth et al, 1992(a), 1992(b), 1992(c), 1992(d), 1992(e), Tagun & Boxall 2018
Sediment dwellers	Acute	LC_{50} 39 mg ac/kg dry sediment (ds)	10	3.9 mg ac/kg ds	Bradley 2015a
Adult bees	Acute contact	LD_{50} 16 µg ac/bee	2.5	6.4 µg ac/bee	Bull & Wilkinson 1987
	Acute oral	LD_{50} 13 µg ac/bee	2.5	5.2 µg ac/bee	Bull & Wilkinson 1987
Foliar arthropods	Contact	LR_{50} 8.2 g ac/ha	1	8.2 g ac/ha	Austin 1999a
Ground arthropods	Contact	ER_{50} >600 g ac/ha	1	600 g ac/ha	Petto 1993
Soil macro-organisms	Acute	LC_{50} 1000 mg ac/kg ds	10	100 mg ac/kg ds	Edwards & Coulson 1993
Terrestrial plants	Post-emergent	$LLHR_5$ 11 g ac/ha	1	11 g ac/ha	Canning & White 1992, Martin 2014b

*Aquatic endpoints have been adjusted to account for rapid dissipation from the water column under natural conditions (adjusted endpoint = measured endpoint / (1 - EXP (exposure days * (-ln(2)/DT50 7.0 days))) * (exposure days * ln(2)/DT50 7.0 days)

6.4 Risks to non-target species

6.4.1 Terrestrial vertebrates

Dietary exposure to terrestrial vertebrates is possible through pre-harvest cotton desiccation, pulse spray topping, or general weed control. Use situations were divided into crop groups, based on EFSA 2009, that have similar growth patterns. Application techniques such as spot spraying and optical spot spraying were considered where relevant.

Terrestrial vertebrate risks from contaminated food are assessed using a tiered approach. Acute risk characterisation simulates a worst-case scenario assuming 100% dietary intake from the treated zone on the day of application, while chronic risk modelling integrates a proportion of diet obtained from the treated area over a period post-application. For Tier-1 assessment, the APVMA utilises EFSA (2009) generic focal species, which are considered protective of species that occur in Australia. The risk assessment was further refined using information provided during public consultation and weight-of-evidence arguments, where appropriate.

For birds, based on the submitted information and refined assessments, the maximum supported rates are:

- 231 g ac/ha (or 2× 144 g ac/ha, with a 7-day interval) for general weed control in fallow, hops, market gardens, nurseries, row crops, potatoes (pre/early emergence), rice (pre/post sowing), and vegetables;
- 1140 g ac/ha for industrial vegetation management, public service areas, and rights of way;
- 187 g ac/ha for pasture (includes hay freezing, spray topping to reduce seed set, prevention of ryegrass toxicity, perennial grass seed crops and kikuyu/paspalum pasture);
- 1295 g ac/ha as a cotton desiccant;
- 226 g ac/ha (ungrazed) or 213 g ac/ha (grazed) for lucerne;
- 137 g ac/ha (over the top) or 103 g ac/ha (inter-row) for sugarcane;
- 213 g ac/ha for peanuts;
- 226 g ac/ha for pre-harvest application to potatoes;
- 1057 g ac/ha for spray topping in pulses; and
- 377 g ac/ha (or 2× 270 g ac/ha, with a 14-day interval) for orchards, tree crops and vineyards

For mammals, quantitative refinements have been used to account for non-eutherian daily energy expenditure, a 50 g small herbivore body weight adjustment to reflect Australian fauna, in addition to other modifications to the risk assessment. Based on the updated assessments, the maximum supported rates are:

- 675 g ac/ha for general weed control in fallow, hops, market gardens, nurseries, row crops, potatoes (pre/early emergence), rice (pre/post sowing), and vegetables;
- 1140 g ac/ha for industrial vegetation management, public service areas, and rights of way;
- 54 g ac/ha for pasture (includes hay freezing, spray topping to reduce seed set, prevention of ryegrass toxicity, perennial grass seed crops and kikuyu/paspalum pasture);
- 218 g ac/ha as a cotton desiccant;
- 600 g ac/ha (ungrazed) or 355 g ac/ha (grazed) for lucerne;
- 400 g ac/ha (over the top and inter-row spraying) for sugarcane;
- 355 g ac/ha for peanuts;
- 363 g ac/ha for pre-harvest application to potatoes;
- 200 g ac/ha for spray topping in pulses; and
- 54 g ac/ha (or 2× 39 g ac/ha, with a 14-day interval) for orchards, tree crops and vineyards

A full assessment for terrestrial vertebrates for the different use patterns is presented in Appendix C. The risk assessment conclusions are summarised in Table 32. Uses that exceed the maximum supported rate are not supported unless application is restricted to the maximum supported rate indicated in Table 32 (note that the rates quoted in this section reflect paraquat alone and do not account for the risk from the combination of paraquat and diquat which is considered in Section 6.5).

For use patterns where an acceptable risk can be concluded, the following protection labelling is appropriate.

> *Toxic to birds and native mammals. However, the use of this product as directed is not expected to have adverse effects on birds or native mammals.*

Paraquat is not expected to bioaccumulate in biota based on its low octanol-water partition coefficient. Therefore, a food chain assessment is not necessary.

Table 32: Paraquat – Summary of risk assessment outcomes for terrestrial vertebrates

Category	Situation	Rate range (g ac/ha)[18]	Wild mammal assessment	Bird assessment	Maximum supported rate[19]
General weed control	Fallow (optical spot spraying)	1× 750-2250 (225-675, FFT 0.3)	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Fallow	1× 150-1505	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Market gardens, row crops, vegetables	1× 300-600	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Market gardens, row crops, vegetables (shielded inter-row sprayers)	1× 300-600	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Hops, rice (pre/post sowing), potatoes (pre/early emergence)	1× 185-400	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Industrial vegetation management	1× 390-1140	Acceptable up to 1140 g ac/ha (WOE)	Acceptable up to 1140 g ac/ha (WOE)	1140 g ac/ha (WOE)
	Pasture (includes hay freezing, spray topping to reduce seed set, prevention of ryegrass toxicity, perennial grass seed crops and kikuyu/paspalum pasture)	1× 100-600	Acceptable up to 54 g ac/ha	Acceptable up to 187 g ac/ha	54 g ac/ha
	Lucerne (ungrazed before spraying)	1× 300-600	Acceptable up to 600 g ac/ha (WOE)	Acceptable up to 226 g ac/ha	226 g ac/ha
	Peanuts (BBCH 10-19)	1× 100-250	Acceptable up to 355 g ac/ha	Acceptable up to 213 g ac/ha	213 g ac/ha

[18] Values in parentheses are the rates adjusted for the fraction of the field treated (FFT)

[19] The maximum supported rate represents the application rate per application, for the stated number of applications and interval (e.g. for 2 applications and a 7-day interval a maximum rate of 144 g ac/ha would be per application, for this number of applications and interval)

Category	Situation	Rate range (g ac/ha)[18]	Wild mammal assessment	Bird assessment	Maximum supported rate[19]
	Sugarcane (over the top spray)	1× 300-400	Acceptable up to 400 g ac/ha (WOE)	Acceptable up to 137 g ac/ha	137 g ac/ha
	Sugarcane (inter-row spray)	1× 300-400	Acceptable up to 400 g ac/ha (WOE)	Acceptable up to 103 g ac/ha	103 g ac/ha
	Orchards, bananas	1× 175-1120	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Spot spray in orchards, bananas	1× 390-1120 (156-448, FFT 0.4)	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Potatoes (pre-harvest)	1× 648-700	Acceptable up to 363 g ac/ha	Acceptable up to 226 g ac/ha	226 g ac/ha
	Spray topping in pulses	1× 200	Acceptable up to 200 g ac/ha (WOE)	Acceptable up to 1057 g ac/ha	200 g ac/ha (WOE)
	Vineyards	1× 390-810	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Spot spray in vineyards	1× 390-810 (156-324, FFT 0.4)	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
Combination products containing diquat	Fallow (minimal disturbance)	2× 162-432 (7d interval)	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 144 g ac/ha	144 g ac/ha
	Fallow (minimal disturbance)	1× 162-432	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Fallow (full disturbance)	1× 81-324	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Market gardens, nurseries, potatoes (pre/early emergence), rice (pre-emergence), vegetables	1× 216-432	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Spot spray in market gardens, nurseries, potatoes (pre/early emergence)	1× 324-432 (130-173, FFT 0.4)	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	231 g ac/ha
	Cotton desiccant	1× 162-216	Acceptable up to 218 g ac/ha	Acceptable up to 1295 g ac/ha	218 g ac/ha
	Pasture	1× 108-432	Acceptable up to 54 g ac/ha	Acceptable up to 187 g ac/ha	54 g ac/ha
	Public service areas, rights of way	1× 324-432	Acceptable up to 1140 g ac/ha (WOE)	Acceptable up to 1140 g ac/ha (WOE)	1140 g ac/ha (WOE)
	Spot spray in public service areas, rights of way	1× 324-432 (130-173, FFT 0.4)	Acceptable up to 1140 g ac/ha (WOE)	Acceptable up to 1140 g ac/ha (WOE)	1140 g ac/ha (WOE)
	Lucerne (grazed before spraying)[20]	1× 216-324	Acceptable up to 355 g ac/ha	Acceptable up to 213 g ac/ha	213 g ac/ha

[20] Where grazing occurs immediately before application for lucerne, the risk assessment only considers up to BBCH 19 to account for the limited crop cover

Category	Situation	Rate range (g ac/ha)[18]	Wild mammal assessment	Bird assessment	Maximum supported rate[19]
	Sugarcane (over the top spray)	1× 162-270	Acceptable up to 270 g ac/ha (WOE)	Acceptable up to 137 g ac/ha	137 g ac/ha
	Sugarcane (inter-row spray)	1× 162-270	Acceptable up to 270 g ac/ha (WOE)	Acceptable up to 103 g ac/ha	103 g ac/ha
	Potatoes (pre-harvest)	1× 432	Acceptable up to 363 g ac/ha	Acceptable up to 226 g ac/ha	226 g ac/ha
	Spot spray in potatoes (pre-harvest)	1× 432 (173, FFT 0.4)	Acceptable up to 363 g ac/ha	Acceptable up to 226 g ac/ha	226 g ac/ha
	Forests, orchards, plantations, bananas, duboisia, tea tree	1× 216-432	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Spot application in orchards, plantations, bananas, duboisia	1× 216-432 (11-173, FFT 0.4)	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Spot application in avocado, custard apples, lychees, mangos	2× 162-324 (14d interval) (89-179, FFT 0.4)	Acceptable up to 39 g ac/ha	Acceptable up to 270 g ac/ha	39 g ac/ha
	Vineyards	1× 324-432	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Spot application in vineyards	1× 324-432 (130-173, FFT 0.4)	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
Combination products containing amitrole	Fallow (optical spot spraying)	1× 500-1680 (150-504, FFT 0.3)	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	Acceptable up to 231 g ac/ha
	Fallow	1× 112-600	Acceptable up to 675 g ac/ha (WOE)	Acceptable up to 231 g ac/ha	Acceptable up to 231 g ac/ha
	Industrial vegetation management	1× 300-850	Acceptable up to 1140 g ac/ha (WOE)	Acceptable up to 1140 g ac/ha (WOE)	1140 g ac/ha (WOE)
	Spot spray in industrial vegetation management	1× 300-500 (120-200, FFT 0.4)	Acceptable up to 1140 g ac/ha (WOE)	Acceptable up to 1140 g ac/ha (WOE)	1140 g ac/ha (WOE)
	Pasture	1× 75-150	Acceptable up to 54 g ac/ha	Acceptable up to 187 g ac/ha	54 g ac/ha
	Orchards	1× 300-600	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Spot spray in orchards	1× 500 (200, FFT 0.4)	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Potatoes (pre-harvest)	1× 525	Acceptable up to 363 g ac/ha	Acceptable up to 226 g ac/ha	226 g ac/ha
	Vineyards	1× 300-600	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha
	Spot spray in vineyards	1× 500 (200, FFT 0.4)	Acceptable up to 54 g ac/ha	Acceptable up to 377 g ac/ha	54 g ac/ha

6.4.2 Aquatic species

As indicated in Table 31, the RAL for the spray drift assessment is 0.15 µg ac/L for the protection of natural aquatic areas. Risks of spray drift are addressed separately, as needed.

A runoff assessment for paraquat according to a modified version of the APVMA's method to refine estimates of pesticide runoff to waterways considered the lowest RAL values of 0.15 µg ac/L and 3.9 mg ac/kg ds and assumed a runoff event occurs three days after the last application. Two approaches to considering the risk are presented:

a) The assessment establishes the expected runoff exposure assuming the soil in the catchment has reached the SAC-WB concentration – this value then defines both the concentration in the soil and the corresponding K_d value, and every pair of values gives the same conclusion in the modelled scenario (Table 33).

   The Tier 1 (screening) level of assessment is a worst-case scenario where slope is fixed at 8%, which is considered protective of 95% of agricultural activities in Australia. A 3% slope for dryland cropping situations has also been considered. The rainfall value is set at 8 mm, which results in the maximum receiving water concentration using the standard water body of 1 ha and 15 cm initial depth when the worst-case Australian soil profile is used; the catchment is 10 ha. Further, for this worst-case scenario, a fallow/bare soil runoff profile is assessed. The K_d reflects a low absorption capacity soil though the default assumptions of the runoff assessment have not been changed for this screening assessment. In the case of this reconsideration, soils of low clay content are also expected to have correspondingly low paraquat binding capacity.

   Interception has not been considered in the screening assessment as the soil concentration is set at the SAC-WB concentration, and interception is not relevant to establishing this value.

b) The assessment is based on the K_f (17.9) and 1/n (0.41) values for a soil with a low clay content (<10%) (Table 34). The Tier 1 (screening) level of assessment is a worst-case scenario where slope is fixed at 8%, which is considered protective of 95% of agricultural activities in Australia. A 3% slope for dryland cropping situations has also been considered. The rainfall value is set at 8 mm, which results in the maximum receiving water concentration using the standard water body of 1 ha and 15 cm initial depth when the worst-case Australian soil profile is used; the catchment is 10 ha. Further, for this worst-case scenario, a fallow/bare soil runoff profile is assessed. The K_f reflects a low absorption capacity soil though the default assumptions of the runoff assessment have not been changed for this screening assessment.

For the approach using the SAC-WB concentration (Table 33), in both dryland cropping situations (assumed slope of 3%) and the default risk assessment (slope of 8%) there would be unresolved risks for exposure in water and sediment. The assessment assumes that the SAC-WB concentration has been reached for all soils in the catchment. This assumption is not directly related to a specific set of uses (application rates) or a specific soil but rather is based only on a consideration that application of paraquat in the theoretical catchment has led to accumulation in the soil(s) such that the SAC-WB concentration has been reached throughout the catchment. Whether or not this concentration would be reached in practice becomes a critical question for the assessment.

For the lower end of reported SAC-WB concentrations, ~10 mg ac/kg ds, using the APVMA's standard approach to estimating soil concentrations[21] and an application rate of 1140 g ac/ha[22] this would equate to 6.6 years' worth of applications, without considering interception and assuming no degradation.

If interception of 90% were assumed[23] this would represent ~12 years of applications. However, if the rate of degradation for paraquat absorbed to soil is assumed to be 20 years (Dyson & Chapman 1995), the cumulative peak concentration in soil[24] would plateau at ~45 mg ac/kg ds or 25 mg ac/kg ds after more than one hundred years' worth of applications, excluding or including interception (at 90%), respectively. For soils with a clay content of ≤10%, these plateau concentrations are greater than the SAC-WB concentration for 45% or 15% of tested soils, respectively (i.e., 55% and 85% of soils, respectively, would not have reached their paraquat binding capacities). In overview, this implies, at least for soils represented in Dyson et al. (1994), that for only a fraction of soils with clay content of ≤10% would it be theoretically possible to reach the SAC-WB value.

For the approach considering concentration dependence (Table 34), acceptable risks are indicated for all scenarios (slope of 3 or 8%) when the soil DT_{50} for calculating accumulation in soil is 20 years. When the DT_{50} is 60 years an acceptable risk is only indicated for a slope of 3%, though interception of 40% would lead to an acceptable risk for all modelled scenarios (maximum accumulated residues 22 mg ac/kg ds, RQ 0.99). These conclusions are based on 20 years of annual applications, the APVMA's standard timeframe for consideration of accumulation of residues in soil. Over longer timeframes the conclusions would not necessarily apply.

It should be recognised that these are the results of a screening stage assessment that is intentionally conservative (e.g. fixed catchment all of which is treated, 90th percentile slope for Australian agricultural land (8%), worst-case soil profile, and worst-case rainfall). Additionally, the calculated accumulated concentration in soil is expected to be conservative. When exposed to microbial activity paraquat degradation is expected to be more rapid than predicted by the current assessment. General agricultural practice, where paraquat is applied without incorporation into the soil, should increase the scope for some of the applied paraquat to be exposed to microbial degradation, especially when the rate of absorption of paraquat into the soil has been reduced, either due to the composition of the soil matrix or because more accessible sites for paraquat absorption have been saturated.

Based on the preceding modelling assumptions, if a soil's SAC-WB value were reached, the risk would be unresolved. However, as also noted, reaching the SAC-WB value would only be theoretically possible for a small fraction of tested soils with clay content ≤10%. Accounting for concentration dependence, after 20 years accumulation the risk is expected to be acceptable. An RQ value >1 is indicated if the DT_{50} is assumed to be 60 years. However, there is reason to expect the predicted accumulation of paraquat to be conservative, and the screening stage risk assessment is inherently conservative, such that at higher tiers of assessment an acceptable

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[21] Concentration in the top 5 cm of soil (mg ac/kg ds) = application rate (g ac/ha) ⁄ 750, this calculation assumes a dry soil bulk density of 1500 kg/m^3

[22] 1140 g ac/ha is at the upper end of actual on-label application rates and has been used for all calculations in this discussion to aid comparison. After accounting for spot spraying and optical spot spraying the maximum on-label rate is currently 1505 g ac/ha.

[23] Concentration in the top 5 cm of soil (mg ac/kg ds) = application rate (g ac/ha) ⁄ 750 × (1 – F_{int} × 0.5), where F_{int} is the interception factor (between 0-1) and half the intercepted fraction is assumed to be washed into the soil by irrigation or rainwater

[24] Cumulative peak concentrations in soil are calculated using the same approach as the HSE PEC soil calculator (https://www.hse.gov.uk/pesticides/data-requirements-handbook/fate/environmental-fate-models.htm).

risk could be expected (after considering factors such as local slope values, rainfall estimates and real-world cropping patterns). Given the available evidence it is not considered necessary to conduct further higher tier analyses, and the risk is concluded to be acceptable for the currently approved use rates.

Because the assessment assumes that a runoff event occurs 3 days after application, the following restraints are recommended for the supported uses.

DO NOT apply if heavy rains or storms are forecast within 3 days.
DO NOT irrigate to the point of field runoff for at least 3 days after application.

Table 33: Assessment of runoff risks to aquatic species – SAC-WB approach

Parameter		Worst-case scenario Sands (clay ≤10%)			
		8% slope		3% slope	
Soil					
Exposure rate	(g/ha)	8250 (1.0th percentile)	16875 (10th percentile)	8250 (1.0th percentile)	16875 (10th percentile)
Soil DT_{50}	(d)	1000	1000	1000	1000
K_d	(L/kg)	1100 (1.0th percentile)	2250 (10th percentile)	1100 (1.0th percentile)	2250 (10th percentile)
Rainfall – P	(mm)	8.00	8.00	8.00	8.00
Runoff – Q	(mm)	1.34	1.34	1.34	1.34
$Cr_{soil\ surface}$	(fraction)	0.00091	0.00044	0.00091	0.00044
slope factor – F	(fraction)	0.26	0.26	0.077	0.077
Runoff	(% applied)	0.000020	0.0000098	0.0000059	0.0000029
Water					
PEC	(µg/L)	0.96	0.96	0.28	0.28
RAL	(µg/L)	0.15	0.15	0.15	0.15
Risk quotient	(fraction)	6.4	6.4	1.9	1.9
Sediment					
PEC	(mg/kg)	18	18	5.3	5.3
RAL	(mg/kg)	3.9	3.9	3.9	3.9
Risk quotient	(fraction)	4.6	4.6	1.4	1.4

Exposure rate represents the SAC-WB soil concentration (mg ac/kg ds) for the Xth percentile of soils with a clay content ≤10% (1.0th percentile 11.0 mg ac/kg ds, 10th percentile 22.5 mg ac/kg ds) converted to an application rate that would lead to the same concentration in the top 5 cm of soil (i.e. SAC-WB * 750 = exposure rate)

Soil DT_{50} and K_d from Table 28

Rainfall P value is default for Tier 1

Runoff Q value = (((-0.000196 × (rain^3)) + (0.0232 × (rain^2))) + (-0.00520 × rain)); runoff curve for worst-case Australian soil profile

$Cr_{soil\ surface}$ = EXP(-3 × ln(2) ⁄ DT_{50soil}) × (1 ⁄ (1 + K_d))

Slope factor F = (0.02153 × slope + 0.001423 × $slope^2$), where the slope is 8% (default) or 3% for dryland cropping regions

Runoff (% applied) = Q ⁄ P × F × $Cr_{soil\ surface}$ × 0.5

PEC (water) = application rate × %runoff ⁄ 100 × 10 ⁄ (1500 + 134) × 1000

PEC (sediment) = PEC (water) × (0.8 + (0.2 × K_P ⁄ 1000 × 2400)) ⁄ 1280, where K_P 50000 (from Table 28)

RAL = regulatory acceptable level (from Table 31)

RQ = risk quotient = PEC ⁄ RAL, where acceptable RQ ≤1

Table 34: Assessment of runoff risks to aquatic species – concentration dependent approach

Parameter		Worst-case scenario Sands (clay ≤10%)			
		DT_{50} 20 years for accumulation		DT_{50} 60 years for accumulation	
		8% slope	3% slope	8% slope	3% slope
Soil					
Exposure rate	(g/ha)	16500	16500	20250	20250
Soil DT_{50}	(d)	7300	7300	21900	21900
K_f	(mL/kg)	17.9	17.9	17.9	17.9
1/n		0.41	0.41	0.41	0.41
Rainfall – P	(mm)	8.00	8.00	8.00	8.00
Runoff – Q	(mm)	1.34	1.34	1.34	1.34
$Cr_{soil\ surface}$	(fraction)	0.070	0.070	0.091	0.091
slope factor – F	(fraction)	0.26	0.077	0.26	0.077
Runoff	(% applied)	0.0015	0.00045	0.0020	0.00059
Water					
PEC	(µg/L)	0.15	0.04	0.24	0.070
RAL	(µg/L)	0.15	0.15	0.15	0.15
Risk quotient	(fraction)	0.99	0.29	**1.6**	0.47
Sediment					
PEC	(mg/kg)	2.8	0.82	4.5	1.3
RAL	(mg/kg)	3.9	3.9	3.9	3.9
Risk quotient	(fraction)	0.71	0.21	**1.1**	0.34

Scenarios are based on annual applications of 1 × 1140 g ac/ha for 20 years with no interception and soil DT_{50} of 20 or 60 years. Exposure rate is back-calculated from maximum predicted annual peak concentration in top 5-cm of soil (i.e. peak soil concentration * 750 = exposure rate). The peak accumulated soil concentrations are:

22 mg ac/kg ds with DT_{50} of 20 years

27 mg ac/kg ds with DT_{50} of 60 years

Soil DT_{50}, K_f and 1/n from Table 28

Rainfall P value is default for Tier 1

Runoff Q value = (((-0.000196 × (rain^3)) + (0.0232 × (rain^2))) + (-0.00520 × rain)); runoff curve for worst-case Australian soil profile

$Cr_{soil\ surface}$ = EXP(-3 × ln(2) ⁄ DT_{50soil}) × (1 ⁄ (1 + (application rate ⁄ 750) ⁄ (10^((Log$_{10}$(application rate ⁄ 750) – Log$_{10}$(K_f)) ⁄ 1/n))))

Slope factor F = (0.02153 × slope + 0.001423 × slope^2), where the slope is 8% (default) or 3% for dryland cropping regions

Runoff (% applied) = Q ⁄ P × F × $Cr_{soil\ surface}$ × 0.5

PEC (water) = application rate × %runoff ⁄ 100 × 10 ⁄ (1500 + 134)

PEC (sediment) = PEC (water) × (0.8 + (0.2 × K_P ⁄ 1000 × 2400)) ⁄ 1280, where K_P 50000 (from Table 28)

RAL = regulatory acceptable level (from Table 31)

RQ = risk quotient = PEC ⁄ RAL, where acceptable RQ ≤1

6.4.3 Bees

For spray applications, risks to bees foraging in treated areas are assessed using a tiered approach. A screening level risk assessment assumes the worst-case scenario of a direct overspray of blooming plants that are frequented by bees in order to identify those substances and associated uses that do not pose a risk. Risks of exposure to foliar residues of paraquat (contact exposure) were acceptable at the highest application rate of 1140 g ac/ha (Table 35). Acceptable risks of oral exposure (via pollen and nectar) to foraging bees could only be concluded at rates up to 175 g ac/ha. To refine the risk assessment 90th percentile RUD values for nectar and pollen (from EFSA 2013b) were used to calculate estimated exposure concentrations (EECs). Based on the refined assessment an acceptable risk can be concluded at up to 1140 g ac/ha. No protection statement is required. The RAL for spray drift assessment for pollinator areas is 2667 g ac/ha based on the contact LD_{50} 16 µg ac/bee and a conversion factor of LOC 0.4 / ExpE 2.4 * 1000 as per APVMA's Spray drift risk assessment manual (SDRAM): https://apvma.gov.au/node/51826. The risk assessment for spray drift is discussed in section 7 below.

Table 35: Screening level assessment of risks to bees

Life stage	Exposure	Rate (g/ha)	Predicted total dose (µg/bee)	RAL (µg/bee)	RQ
Screening level assessment (pollen & nectar EEC (mg/kg) = rate × 98 ⁄ 1000)					
Adults	Acute contact	1140	2.7	6.4	0.43
	Acute oral	1140	33	5.2	**6.3**
		1125	32	5.2	**6.2**
		1120	32	5.2	**6.2**
		810	23	5.2	**4.5**
		800	23	5.2	**4.4**
		720	21	5.2	**4.0**
		700	20	5.2	**3.9**
		600	17	5.2	**3.3**
		420	12	5.2	**2.3**
		400	11	5.2	**2.2**
		300	8.6	5.2	**1.7**
		250	7.2	5.2	**1.4**
		200	5.7	5.2	**1.1**
		175	5.0	5.2	1.0

Life stage	Exposure	Rate (g/ha)	Predicted total dose (µg/bee)	RAL (µg/bee)	RQ
Refined assessment (pollen EEC (mg/kg) = rate × 52 ⁄ 1000 + nectar EEC (mg/kg) = rate × 11 ⁄ 1000)					
Adults	Acute oral	1140	3.7	5.2	0.70

Screening level pollen & nectar EEC based on default RUD 98

Refined assessment based on 90th percentile RUD values of 52 mg/kg for pollen and 11 mg/kg for nectar from EFSA (2013b)

Predicted total dose calculated using USEPA BeeREX tool for adult worker bee foraging for nectar and larval drone within the hive

RAL = regulatory acceptable level (from Table 31)

RQ = risk quotient = PEC / RAC, where acceptable RQ ≤1

6.4.4 Other arthropod species

Commercial use of predatory or parasitic arthropods in integrated pest management programs can occur in a wide range of agricultural industries. For broad-spectrum herbicides such as paraquat, exposure of natural populations of arthropod species that are beneficial to agricultural systems is also possible. The risk assessment assumes that arthropods are exposed to fresh-dried residues within the treatment area immediately after the last application. Acceptable risks to predatory and/or parasitic arthropods could not be concluded for any of the assessed scenarios (Table 36). Therefore, the following protection statement is recommended for all registered uses of paraquat.

> *Toxic to beneficial arthropods. Not compatible with integrated pest management (IPM) programs utilising beneficial arthropods. Minimise spray drift to reduce harmful effects on beneficial arthropods in non-crop areas.*

Table 36: Assessment of risks to other non-target arthropods

Scenario	Group	Exposure	Rate (g/ha)	RAL (g/ha)	RQ
Worst-case (1× 2250 g ac/ha)	Foliar arthropods	Contact	2250	8.2	**274**
	Ground arthropods	Contact	2250	600	**3.8**
Best-case (1× 175 g ac/ha)	Foliar arthropods	Contact	175	8.2	**21**
	Ground arthropods	Contact	175	600	0.29

RAL = regulatory acceptable level (from Table 31)

RQ = risk quotient = PEC / RAL, where acceptable RQ ≤1

6.4.5 Soil organisms

The risk assessment assumes soil organisms are exposed to accumulated residues in the top 5-cm after 20 years of use. Assuming annual use at the highest rate of 2250 g ac/ha with no foliar interception, the peak concentration was predicted to be 13 mg ac/kg dry soil (acute exposure scenario), while the steady state concentration was predicted to be 10 mg ac/kg dry soil (chronic exposure scenario). Risks due to acute exposure of soil organisms were determined to be acceptable under this worst-case scenario (Table 37).

The available field studies imply that, when paraquat has not exceeded a given soil's strong absorption capacity, no adverse effects are expected for soil dwelling macro- or micro-organisms, as any paraquat is essentially biologically unavailable. If the strong absorption capacity of a soil is exceeded, i.e. paraquat is present in solution in soil pore water, then adverse effects may occur amongst soil macro-organisms. Soil micro-organisms are not expected to be affected given their intrinsic reproductive capacity and involvement in the degradation of bioavailable paraquat. For most soils, the strong absorption capacity of the soil will be hundreds of times the annual application rate and it would take further inputs to reach or exceed the SAC-WB value, at which adverse effects have been observed. It has also been observed that under normal agricultural practice (multiple years of accumulated residues, at ≤2.25 kg ac/ha) the rate of degradation of paraquat is expected to be greater than for the single applications tested in the field studies, reducing the likelihood that adverse concentrations will be reached. Given the available evidence, long-term risks to soil organisms are concluded to be acceptable and no protection statements are therefore required.

Table 37: Screening level assessment of risks to soil organisms (worst-case scenario)

Group	Exposure	Annual rate (g/ha)	PEC (mg/kg dry soil)	RAL (mg/kg dry soil)	RQ
Macro-organisms	Acute	2 250	13	100	0.13

Worst-case scenario based on 1× 2250 g ac/ha applied annually for 20 years with no interception and soil DT_{50} 1000 d

Acute PEC is based on maximum predicted annual peak concentration in top 5 cm

RAL = regulatory acceptable level (from Table 31)

RQ = risk quotient = PEC / RAC, where acceptable RQ ≤1

6.4.6 Non-target terrestrial plants

As indicated in Table 31, the RAL for the spray drift assessment is 11 g ac/ha for the protection of vegetation areas. Risks of spray drift are addressed separately.

6.5 Combination toxicity

6.5.1 Assessment scenarios for diquat/paraquat combination products

The risks for the individual actives, diquat and paraquat, have been assessed separately. For combination products containing 115 g/L diquat and 135 g/L paraquat risks of combination toxicity to non-target species have also been assessed. The relevant scenarios for use of these products are summarised in Table 38.

Table 38: Diquat (115 g/L)/paraquat (135 g/L) combination products: environmental risk assessment scenarios

Crop/situation	Product rate range (L/ha)	Diquat rate range (g ac/ha)	Paraquat rate range (g ac/ha)	Total actives rate range (g acs/ha)
As an aid to cultivation in fallow (full disturbance)	0.6 to 3.2	69 to 368	81 to 432	150 to 800

Crop/situation	Product rate range (L/ha)	Diquat rate range (g ac/ha)	Paraquat rate range (g ac/ha)	Total actives rate range (g acs/ha)
As an aid to cultivation in fallow (minimum disturbance)	0.6 to 3.2	69 to 368	81 to 432	150 to 800
As an aid in post-harvest weed control in fallow (minimum disturbance)	1.6 to 2.4	184 to 276	216 to 324	400 to 600
As an aid in establishing sugarcane or controlling weeds in a fallow prior to sugarcane	1.2 to 3.2	138 to 368	162 to 432	300 to 800
Sugarcane plant and ratoon	1.2 to 2.0	138 to 230	162 to 270	300 to 500
Desiccant to aid harvest in cotton	1.2 to 1.6	138 to 184	162 to 216	300 to 400
Lucerne (established at least 1 year old)	1.6 to 2.4	184 to 276	216 to 324	400 to 600
Public Service Areas, Rights-of-Way	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Market Gardens and Nurseries	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Orchards (including Bananas), Vineyards and Forests–ring weeding around trees with brown bark and strip spraying in Orchards and Vineyards	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Hazelnut plantations	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Pistachio nuts	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Walnuts	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Pre-crop emergence weed control	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Long-term weed control[25]	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Potatoes weed control	2.4 to 3.2	276 to 368	324 to 432	600 to 800
(spot spray)	2.4 to 3.2	276 to 368	324 to 432	600 to 800

[25] The use situation for 'long term weed control' is not sufficiently well defined to identify the relevant risk assessment scenario(s) for terrestrial vertebrates. Therefore, this use cannot be considered further without clarification of the use situation, so that an appropriate risk assessment can be conducted.

Crop/situation	Product rate range (L/ha)	Diquat rate range (g ac/ha)	Paraquat rate range (g ac/ha)	Total actives rate range (g acs/ha)
Potatoes weed destruction prior to digging	3.2	368	432	800
(spot spray)	3.2	368	432	800
Avocados, custard apples, lychees, mangoes (spot spray)	1.2 to 2.4	138 to 276	162 to 324	300 to 600
Rice	1.6 to 3.2	184 to 368	216 to 432	400 to 800
Pasture (Kikuyu/paspalum)	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Pasture	0.8 to 2.4	92 to 276	108 to 324	200 to 600
Duboisia	2.4 to 3.2	276 to 368	324 to 432	600 to 800
Tea-trees	1.6 to 3.2	184 to 368	216 to 432	400 to 800

6.5.2 Effects on non-target species

Please refer to Appendix B (Table 68 to Table 73) for the predicted diquat/paraquat combination toxicity values for non-target species. For further details on the estimation method, please refer to the APVMA Risk Assessment Manual – Environment. All combination toxicity endpoints are expressed in terms of total active constituents (acs).

A representative combination product containing 115 g/L diquat and 135 g/L paraquat had moderate toxicity to rats (LD_{50} 119 mg acs/kg bw, *Rattus norvegicus*). No data are available on the toxicity of a representative combination product containing 115 g/L diquat and 135 g/L paraquat to any other non-target species. Therefore, combination toxicity to non-target species was estimated assuming additive toxicity of the active constituents. Based on available data, the diquat/paraquat combination products were predicted to have high toxicity to mammals (geomean LD_{50} 76 mg acs/kg bw, 4 mammal species) and birds (geomean LD_{50} 62 mg acs/kg bw, 3 bird species). Therefore, the following hazard statement is recommended on diquat/paraquat combination product labels (followed by an appropriate risk management statement).

> *Toxic to birds and native mammals.* However, the use of this product as directed is not expected to have adverse effects on birds and native mammals.

In aquatic systems, diquat and paraquat dissipate quickly from the water column under natural conditions due to rapid adsorption to sediment and suspended particulates; therefore, the aquatic endpoints were first adjusted to account for their expected dissipation under natural conditions prior to deriving the combination toxicity estimates. Although field data on diquat suggest a more rapid half-life, the more conservative water DT_{50} of 7.0 days for paraquat has been utilised for both chemicals to avoid artificially skewing the relative toxicity contributions toward paraquat.

After considering the exposure periods for each of the aquatic endpoints and rapid dissipation under natural conditions, the diquat/paraquat combination products were predicted to have moderate toxicity to fish (LC_{50} 1.7 mg acs/L for most sensitive species) and aquatic invertebrates (lowest LC_{50} 0.15 mg acs/L, *Hyalella azteca*), and high toxicity to primary producers (geomean E_rC_{50} 0.010 mg acs/L, 3 algal and 2 aquatic plant species). Therefore, the following protection statement is recommended on diquat/paraquat combination product labels.

> Very toxic to aquatic life. DO NOT contaminate wetlands or watercourses with this product or used containers.

Based on available data, the diquat/paraquat combination products were predicted to have moderate toxicity to bees by contact exposure (LD_{50} 26 µg acs/bee, *Apis mellifera*) and oral exposure (LD_{50} 16 µg acs/bee, *Apis mellifera*). For the protection of pollinator areas, the RAL for the spray drift assessment is 4,333 g acs/ha based on the predicted contact LD_{50} of 26 µg acs/bee and a conversion factor of LOC 0.4 / ExpE 2.4 * 1,000 as per the APVMA's Spray drift risk assessment manual (SDRAM).

Based on the available data, the LR_{50} values for the indicator species of predatory arthropods (predatory mite *Typhlodromus pyri*) were predicted to be 2.3 g acs/ha (tier 1) and 5.6 g acs/ha (tier 2). Insufficient data were available on the indicator species of parasitic arthropods (parasitic wasp *Aphidius rhopalosiphi*) to estimate combination toxicity. The diquat/paraquat combination products were not expected to be toxic to ground arthropods such as rain beetles (*Pterostichus melanarius*), wolf spiders (*Pardosa* sp.), and rove beetles (*Aleochara bilineata*).

Based on available data, any toxicity to soil macro-organisms such as earthworms would be attributed to diquat. The diquat/paraquat combination products are not expected to adversely influence soil processes such as nitrification.

Because both diquat and paraquat have low toxicity to non-target terrestrial plants following pre-emergent exposure (seedling emergence tests), hence post-emergent exposure data (vegetative vigour tests) were alone considered. Based on available data, predicted ER_{50} values following post-emergent exposure ranged from 19 g acs/ha for the most sensitive species (cabbage or rough cocklebur) to >446 g acs/ha for common bean. An SSD analysis was performed on the post-emergent ER_{50} values for 6 non-target terrestrial plant species. An HR_5 of 15 g acs/ha was derived (Table 39), which is lower than the lowest ER_{50} value. As such, 15 g acs/ha was selected as the RAL for the protection of vegetation areas.

The regulatory acceptable levels for the environmental risk assessment are listed in Table 40, which are based on predicted toxicity values. The RAL values for the spray drift assessment are 1.0 µg acs/L for the protection of natural aquatic areas, 4,333 g acs/ha[26] for the protection of pollinator areas, and 15 g acs/ha for the protection of vegetation areas.

Table 39: Diquat (115 g/L)/paraquat (135 g/L) combination products - Predicted toxicity endpoints for non-target terrestrial plants (post-emergent exposure) used in SSD analysis

Species	Predicted ER_{50}
Sensitive species (Brassica oleracea/Xanthium strumarium)	19 g acs/ha
Beta vulgaris	50 g acs/ha
Lolium perenne	61 g acs/ha
Allium cepa	173 g acs/ha
Zea mays	206 g acs/ha
Phaseolus vulgaris	>446 g acs/ha

[26] RAL = LD_{50} × LOC 0.4 ⁄ ExpE 2.4 × 1000

Species	Predicted ER_{50}
	HR_5 15 g acs/ha (95% CI 2.4-78)[27]

Table 40: Diquat (115 g/L)/paraquat (135 g/L) combination products: regulatory acceptable levels for non-target species

Group	Exposure	Endpoint	AF	RAL
Mammals	Acute	LD_{50} 76 mg acs/kg bw	10	7.6 mg acs/kg bw
Birds	Acute	LD_{50} 62 mg acs/kg bw	10	6.2 mg acs/kg bw
Aquatic species	Acute	EC_{50} 10 µg acs/L*	10	1.0 µg acs/L
Adult bees	Contact	LD_{50} 26 µg acs/bee	2.5	10 µg acs/bee
	Oral	LD_{50} 16 µg acs/bee	2.5	6.4 µg acs/bee
Foliar arthropods	Contact	LR_{50} 5.6 g acs/ha	1	5.6 g acs/ha
Ground arthropods	Contact	Not expected to be toxic		
Soil macro-organisms	Acute	Any toxicity would be attributed to diquat		
Soil micro-organisms	Chronic	Not expected to be toxic		
Terrestrial plants	Post-emergent	HR_5 15 g acs/ha	1	15 g acs/ha

*Aquatic endpoints have been adjusted to account for rapid dissipation from the water column under natural conditions (adjusted endpoint = measured endpoint / (1 - EXP (exposure days * (-ln(2)/DT_{50} 7.0 days))) * (exposure days * ln(2)/DT_{50} 7.0 days)

6.5.3 Risks to non-target species

The risk assessment for diquat/paraquat combination products considers only short-term risks to non-target species following direct exposure to combined residues of the active constituents (diquat + paraquat cations) immediately after one application.

The assessment for terrestrial vertebrates assumes 100% of food items are obtained from the treatment area on the day of application. The use patterns were divided into groups which consist of crops that have similar growing patterns (Table 41). The risk from the combined exposure to paraquat and diquat is considered in Table 42. The conclusion for each crop group and whether weight of-evidence arguments are considered sufficient to resolve the risk is summarised in the text below and in Table 43.

Bare soil crop group

Mammals – There are unresolved risks to small omnivorous mammals at >531 g acs/ha. However, the risk is concluded to be acceptable at up to the maximum on-label use rate (800 g acs/ha) based on the same weight of

[27] Calculated using Shinyssdtools (Version 0.4.0) (Dalgarno 2021; https://bcgov-env.shinyapps.io/ssdtools/)

evidence argument as considered for paraquat, e.g., small mammals are not expected to routinely use environments with limited ground cover.

Birds – There are unresolved risks to small granivorous birds at >251 g acs/ha, small omnivorous birds at >356 g acs/ha and small insectivorous birds at >569 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Cotton crop group

Mammals – There are unresolved risks to small herbivorous mammals at >271 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Birds – The risk is concluded to be acceptable (Table 42) and no further consideration is required.

Grassland crop group – Pasture

Mammals – There are unresolved risks to small herbivorous mammals at >68 g acs/ha, large herbivorous mammals at >286 g acs/ha and small omnivorous mammals at >528 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Birds – There are unresolved risks to small granivorous birds at >251 g acs/ha, large herbivorous birds at >203 g acs/ha and small insectivorous birds at >231 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Grassland crop group – General weed control in public service areas and rights of way

Mammals – There are unresolved risks to small herbivorous mammals at >68 g acs/ha, large herbivorous mammals at >286 g acs/ha and small omnivorous mammals at >528 g acs/ha. However, the risk is concluded to be acceptable at up to the maximum on-label use rate (800 g acs/ha) based on the same weight of evidence argument as considered for paraquat and diquat, e.g. only a small fraction of any given area will be treated, or suitable habitat is expected to be absent.

Birds – There are unresolved risks to small granivorous birds at >251 g acs/ha, large herbivorous birds at >203 g acs/ha and small insectivorous birds at >231 g acs/ha. No suitable weight-of-evidence arguments have been identified to resolve the risk. However, the risk is concluded to be acceptable at up to the maximum on-label use rate (800 g acs/ha) based on the same weight of evidence argument as considered for paraquat and diquat, e.g. only a small fraction of any given area will be treated, or suitable habitat is expected to be absent.

Legume forage crop group

Mammals – The risk is concluded to be acceptable (Table 42) and no further consideration is required.

Birds – There are unresolved risks to small granivorous birds at >251 g acs/ha, small omnivorous birds at >258 g acs/ha and small insectivorous birds at >231 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Maize crop group – Sugarcane

Mammals – There are unresolved risks to small herbivorous mammals at >68 g acs/ha and small omnivorous mammals at >442 g acs/ha. However, the risk is concluded to be acceptable at up to the maximum on-label use rate (500 g acs/ha) based on the same weight of evidence argument as considered for paraquat and diquat, e.g. the risk is concluded to be acceptable for focal species observed to occur in sugarcane.

Birds – There are unresolved risks to medium herbivorous/granivorous birds at >149 g acs/ha, small omnivorous birds at >258 g acs/ha and small insectivorous birds at >231 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Orchard crop group

Mammals – There are unresolved risks to small herbivorous mammals at >68 g acs/ha, large herbivorous mammals at >342 g acs/ha and small omnivorous mammals at >650 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Birds – There are unresolved risks to small granivorous birds at >411 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Potato crop group

Mammals – There are unresolved risks to small herbivorous mammals at >452 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Birds – There are unresolved risks to small insectivorous birds at >246 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Vineyard crop group

Mammals – There are unresolved risks to small herbivorous mammals at >68 g acs/ha, large herbivorous mammals at >342 g acs/ha and small omnivorous mammals at >650 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Birds – There are unresolved risks to small granivorous birds at >411 g acs/ha. A sufficient weight-of-evidence argument has not been identified to resolve the risk.

Risks from runoff of diquat and paraquat to aquatic species are considered separately in the respective risk assessments for the individual actives. Both require the following restraints which also apply to the diquat/paraquat combination products.

> *DO NOT apply if heavy rains or storms are forecast within 3 days.*
>
> *DO NOT irrigate to the point of field runoff for at least 3 days after application.*

The assessment for bees assumes the worst-case scenario of a direct overspray of blooming plants that are frequented by bees in order to identify those substances and associated uses that do not pose a risk. Risks of exposure to foliar residues (contact exposure) were acceptable at the highest application rate of 800 g acs/ha (Table 44). An acceptable risk from oral exposure (via pollen and nectar) could not be concluded based on the screening assessment at the maximum rate 800 g acs/ha. To refine the risk assessment 90th percentile RUD values for nectar and pollen (from EFSA 2013b) were used to calculate estimated exposure concentrations (EECs). Based on the refined assessment an acceptable risk can be concluded at rates up to 800 g acs/ha. No protection statement is required.

The assessment for other arthropod species assumes that predatory and parasitic arthropods are exposed to fresh-dried residues within the treatment area immediately after application. The combination product is not expected to be toxic to ground arthropods. However, risks to foliar arthropods could not be concluded at the lowest rate (Table 45). Therefore, the following protection statement is recommended for all combination products containing 115 g/L diquat and 135 g/L paraquat.

> *Toxic to beneficial arthropods. Not compatible with integrated pest management (IPM) programs utilising beneficial arthropods. Minimise spray drift to reduce harmful effects on beneficial arthropods in non-crop areas.*

No protection statements are required for soil organisms to address risks of diquat or paraquat alone, as per their individual environmental assessments. When considering their combination (115 g/L diquat + 135 g/L paraquat), toxicity to soil macro-organisms such as earthworms would be attributed to diquat.

The combination products are not expected to adversely affect soil processes such as nitrogen transformation, and therefore risks are considered acceptable.

As indicated in the 'Effects on non-target species' Section 6.4.8, the RAL values for the spray drift assessment are 1.0 µg acs/L for the protection of natural aquatic areas, 4,333 g acs/ha for the protection of pollinator areas, and 15 g acs/ha for the protection of vegetation areas. Risks of spray drift are addressed separately, as needed.

Table 41: Diquat (115 g/L) & paraquat (135 g/L) combination products: crop groups for terrestrial vertebrate assessment

EFSA 2009 crop group	Crop / situation	FFT	Application rates (g acs/ha)
Bare soil	As an aid to cultivation in fallow (minimum and full disturbance), post-harvest weed control in fallow, aid in establishing sugarcane, market gardens, nurseries, pre-crop emergence weed control, potatoes (pre-emergence), and rice	1.0	150 to 800
	Spot spraying in market gardens, nurseries, pre-crop emergence weed control, and potatoes (pre-emergence)	0.4	240 to 320
Cotton	Desiccant to aid harvest in cotton	1.0	300 to 400
Grassland	Public service areas, rights-of-way, pasture (including kikuyu/paspalum)	1.0	200 to 800
	Spot spraying in public service areas and rights-of-way	0.4	240 to 320
Legume forage	Lucerne (established at least 1 year old)	1.0	400 to 600
Maize	Sugarcane plant and ratoon	1.0	300 to 500

EFSA 2009 crop group	Crop / situation	FFT	Application rates (g acs/ha)
Orchards	Orchards (including Bananas), and forests–ring weeding around trees with brown bark and strip spraying in orchards, hazelnut plantations, pistachio nuts, walnuts, duboisia, tea-trees	1.0	400 to 800
	Spot spraying in orchards (including Bananas), and forests–ring weeding around trees with brown bark and strip spraying in orchards, hazelnut plantations, pistachio nuts, walnuts, duboisia	0.4	240 to 320
	Spot spraying in avocados, custard apples, lychees, mangoes	0.4	120 to 240
Potatoes	Potatoes weed destruction prior to digging	1.0	800
	Spot spraying in potatoes	0.4	320
Vineyards	Vineyards and strip spraying in vineyards	1.0	600 to 800
	Spot spraying in vineyards	0.4	240 to 320
-	Long-term weed control (including spot spraying)[28]	-	-

Risk assessment scenarios as described in Table 38

Table 42: Diquat (115 g/L)/paraquat (135 g/L) combination products: acute risks to terrestrial vertebrates

Crop group	Generic focal species	Crop stage	Shortcut value	AR (g acs/ha)	DDD (mg acs/kg bw)	RQ	Max (g acs/ha)
Wild mammals (RAL 7.6 mg ac/kg bw)							
Bare soil	Small omnivore	BBCH <10	14.3	800	11	**1.5**	531
			14.3	600	8.6	**1.1**	531
			14.3	400	5.7	0.75	531
			14.3	320	4.6	0.60	531
			14.3	300	4.3	0.56	531
			14.3	240	3.4	0.45	531
			14.3	150	2.1	0.28	531
Cotton	Small herbivore	BBCH ≥50	28.0[a,c]	400	11	**1.5**	271
			28.0[a,c]	300	8.4	**1.1**	271
	Small omnivore	BBCH ≥50	4.3	400	1.7	0.23	1767
			4.3	300	1.3	0.17	1767
	Small insectivore	BBCH ≥20	5.4	400	2.2	0.28	1407
			5.4	300	1.6	0.21	1407
Grassland	Small herbivore	All season	112[a]	800	90	**11.8**	68
			112[a]	600	67	**8.8**	68

[28] The use situation for 'long term weed control' is not sufficiently well defined to identify the relevant risk assessment scenario(s) for terrestrial vertebrates. The risk is concluded to be unacceptable.

Crop group	Generic focal species	Crop stage	Shortcut value	AR (g acs/ha)	DDD (mg acs/kg bw)	RQ	Max (g acs/ha)
			112[a]	320	36	**4.7**	68
			112[a]	240	27	**3.5**	68
			112[a]	200	22	**2.9**	68
	Large herbivore	All season	26.6[b]	800	21	**2.8**	286
			26.6[b]	600	16	**2.1**	286
			26.6[b]	320	8.5	**1.1**	286
			26.6[b]	240	6.4	0.84	286
			26.6[b]	200	5.3	0.70	286
	Small omnivore	New sown or late season	14.4	800	12	**1.5**	528
			14.4	600	8.6	**1.1**	528
			14.4	320	4.6	0.61	528
			14.4	240	3.5	0.45	528
			14.4	200	2.9	0.38	528
	Small insectivore	Late season	5.4	800	4.3	0.57	1407
			5.4	600	3.2	0.43	1407
			5.4	320	1.7	0.23	1407
			5.4	240	1.3	0.17	1407
			5.4	200	1.1	0.14	1407
Legume forage	Small omnivore	BBCH 10-49	11.2[a,c]	600	6.7	0.88	679
			11.2[a,c]	400	4.5	0.59	679
	Small insectivore	BBCH 10-19	7.6	600	4.6	0.60	1000
			7.6	400	3.0	0.40	1000
Maize	Small herbivore	BBCH 10-29	112[a]	500	56	**7.4**	68
			112[a]	300	34	**4.4**	68
	Small omnivore	BBCH 10-29	17.2	500	8.6	**1.1**	442
			17.2	300	5.2	0.68	442
	Small insectivore	BBCH 10-19	7.6	500	3.8	0.50	1000
			7.6	300	2.3	0.30	1000
Orchards	Small herbivore	Ground directed	112[a]	800	90	**11.8**	68
			112[a]	600	67	**8.8**	68
			112[a]	400	45	**5.9**	68
			112[a]	320	36	**4.7**	68
			112[a]	240	27	**3.5**	68
			112[a]	120	13	**1.8**	68
	Large herbivore	Ground directed	22.2[b]	800	18	**2.3**	342
			22.2[b]	600	13	**1.8**	342
			22.2[b]	400	8.9	**1.2**	342
			22.2[b]	320	7.1	0.93	342

Crop group	Generic focal species	Crop stage	Shortcut value	AR (g acs/ha)	DDD (mg acs/kg bw)	RQ	Max (g acs/ha)
			22.2[b]	240	5.3	0.70	342
			22.2[b]	120	2.7	0.35	342
	Small omnivore	Ground directed	11.7[c]	800	9.4	**1.2**	650
			11.7[c]	600	7.0	0.92	650
			11.7[c]	400	4.7	0.62	650
			11.7[c]	320	3.7	0.49	650
			11.7[c]	240	2.8	0.37	650
			11.7[c]	120	1.4	0.18	650
	Small insectivore	Ground directed	5.4	800	4.3	0.57	1407
			5.4	600	3.2	0.43	1407
			5.4	400	2.2	0.28	1407
			5.4	320	1.7	0.23	1407
			5.4	240	1.3	0.17	1407
			5.4	120	0.65	0.09	1407
Potatoes	Small herbivore	BBCH ≥40	16.8[a,c]	800	13	**1.8**	452
			16.8[a,c]	320	5.4	0.71	452
	Large herbivore	BBCH ≥40	3.3[b,c]	800	2.6	0.35	2303
			3.3[b,c]	320	1.1	0.14	2303
	Small omnivore	BBCH ≥40	5.2	800	4.2	0.55	1462
			5.2	320	1.7	0.22	1462
	Small insectivore	BBCH ≥20	5.4	800	4.3	0.57	1407
			5.4	320	1.7	0.23	1407
Vineyards	Small herbivore	Ground directed	112[a]	800	90	**12**	68
			112[a]	600	67	**8.8**	68
			112[a]	320	36	**4.7**	68
			112[a]	240	27	**3.5**	68
	Large herbivore	Ground directed	22.2[b]	800	18	**2.3**	342
			22.2[b]	600	13	**1.8**	342
			22.2[b]	320	7.1	0.93	342
			22.2[b]	240	5.3	0.70	342
	Small omnivore	Ground directed	11.7[c]	800	9.4	**1.2**	650
			11.7[c]	600	7.0	0.92	650
			11.7[c]	320	3.7	0.49	650
			11.7[c]	240	2.8	0.37	650
Birds (RAL 6.2 mg ac/kg bw)							
Bare soil	Small granivore	BBCH <10	24.7	800	20	**3.2**	251
			24.7	600	15	**2.4**	251
			24.7	400	10	**1.6**	251

Crop group	Generic focal species	Crop stage	Shortcut value	AR (g acs/ha)	DDD (mg acs/kg bw)	RQ	Max (g acs/ha)
			24.7	320	7.9	1.3	251
			24.7	300	7.4	1.2	251
			24.7	240	5.9	0.96	251
			24.7	150	3.7	0.60	251
	Small omnivore	BBCH <10	17.4	800	14	2.2	356
			17.4	600	10	1.7	356
			17.4	400	7.0	1.1	356
			17.4	320	5.6	0.90	356
			17.4	300	5.2	0.84	356
			17.4	240	4.2	0.67	356
			17.4	150	2.6	0.42	356
	Small insectivore	BBCH <10	10.9	800	8.7	1.4	569
			10.9	600	6.5	1.1	569
			10.9	400	4.4	0.70	569
			10.9	320	3.5	0.56	569
			10.9	300	3.3	0.53	569
			10.9	240	2.6	0.42	569
			10.9	150	1.6	0.26	569
Cotton	Medium insectivore	BBCH ≥20	3.0	400	1.2	0.19	2067
			3.0	300	0.90	0.15	2067
	Small omnivore	BBCH ≥50	4.4	400	1.8	0.28	1409
			4.4	300	1.3	0.21	1409
Grassland	Small granivore	Late season	24.7	800	20	3.2	251
			24.7	600	15	2.4	251
			24.7	320	7.9	1.3	251
			24.7	240	5.9	0.96	251
			24.7	200	4.9	0.80	251
	Large herbivore	Growing shoots	30.5	800	24	3.9	203
			30.5	600	18	3.0	203
			30.5	320	10	1.6	203
			30.5	240	7.3	1.2	203
			30.5	200	6.1	0.98	203
	Small insectivore	Growing shoots	26.8	800	21	3.5	231
			26.8	600	16	2.6	231
			26.8	320	8.6	1.4	231
			26.8	240	6.4	1.0	231
			26.8	200	5.4	0.86	231
Legume	Small granivore	BBCH 10-49	24.7	600	15	2.4	251

Crop group	Generic focal species	Crop stage	Shortcut value	AR (g acs/ha)	DDD (mg acs/kg bw)	RQ	Max (g acs/ha)
forage			24.7	400	10	1.6	251
	Small omnivore	BBCH 10-49	24.0	600	14	2.3	258
			24.0	400	10	1.5	258
	Small insectivore	BBCH 10-19	26.8	600	16	2.6	231
			26.8	400	11	1.7	231
Maize	Medium herbivore/ granivore	BBCH 10-29	41.7[c]	500	21	3.4	149
			41.7[c]	300	13	2.0	149
	Medium granivore	BBCH 10-29	6.6	500	3.3	0.53	939
			6.6	300	2.0	0.32	939
	Small omnivore	BBCH 10-29	24.0	500	12	1.9	258
			24.0	300	7.2	1.2	258
	Small insectivore	BBCH 10-19	26.8	500	13	2.2	231
			26.8	300	8.0	1.3	231
	Small insectivore/worm feeding	BBCH 10-19	10.5	500	5.3	0.85	590
			10.5	300	3.2	0.51	590
Orchards[29]	Small granivore	Ground directed	15.1[c]	800	12	1.9	411
			15.1[c]	600	9.1	1.5	411
			15.1[c]	400	6.0	0.97	411
			15.1[c]	320	4.8	0.8	411
			15.1[c]	240	3.6	0.58	411
			15.1[c]	120	1.8	0.29	411
	Small insectivore/worm feeding	Ground directed	7.4	800	5.9	0.95	838
			7.4	600	4.4	0.72	838
			7.4	400	3.0	0.48	838
			7.4	320	2.4	0.38	838
			7.4	240	1.8	0.29	838
			7.4	120	0.89	0.14	838
Potatoes	Small omnivore	BBCH ≥40	7.2	800	5.8	0.93	861
			7.2	320	2.3	0.37	861
	Small insectivore	BBCH ≥20	25.2	800	20	3.3	246
			25.2	320	8.1	1.3	246

[a] Refined shortcut value used for risk assessment; small herbivores, bodyweight adjusted to 50 g

[b] Refined shortcut value used for risk assessment; large herbivores, bodyweight adjusted to 1500 g and DEE based on non-eutherian mammals

[c] Refined shortcut value used for risk assessment; adjusted for interception values in EFSA (2020)

[29] Includes use in vineyards

Crop groups and situations as indicated in Table 41

Generic focal species and shortcut values for indicated crop groups from EFSA (2009), unless indicated otherwise

AR (g ac/ha) = application rate

DDD (mg ac/kg bw or mg ac/kg bw/d) = daily dietary dose = AR ⁄ 1000 × shortcut value

RAL = regulatory acceptable level (from Table 40)

RQ = risk quotient = DDD ⁄ RAL, RQ ≤1 indicates an acceptable risk

Table 43: Summary of risk assessment outcomes for risks of combination products containing 115 g/L diquat and 135 g/L paraquat to terrestrial vertebrates

Crop/situation	Product rate range (L/ha)	Wild mammal assessment	Max rate supported (g acs/ha)	Bird assessment	Max rate supported (g acs/ha)
As an aid to cultivation in fallow (full disturbance)	0.6 to 3.2	Yes	800 (WOE)	No	251
As an aid to cultivation in fallow (minimum disturbance)	0.6 to 3.2	Yes	800 (WOE)	No	251
As an aid in post-harvest weed control in fallow (minimum disturbance)	1.6 to 2.4	Yes	800 (WOE)	No	251
As an aid in establishing sugarcane or controlling weeds in a fallow prior to sugarcane	1.2 to 3.2	Yes	800 (WOE)	No	251
Sugarcane plant and ratoon	1.2 to 2.0	Yes	500 (WOE)	No	149
Desiccant to aid harvest in cotton	1.2 to 1.6	No	271	Yes	1409
Lucerne (established at least 1 year old)	1.6 to 2.4	Yes	679	No	231
Public Service Areas, Rights-of-Way	2.4 to 3.2	Yes	800 (WOE)	Yes	800 (WOE)
(spot spray)	2.4 to 3.2	Yes	320 (WOE)	Yes	320 (WOE)
Market Gardens and Nurseries	2.4 to 3.2	Yes	800 (WOE)	No	251
(spot spray)	2.4 to 3.2	Yes	320 (WOE)	No	251

Crop/situation	Product rate range (L/ha)	Wild mammal assessment	Max rate supported (g acs/ha)	Bird assessment	Max rate supported (g acs/ha)
Orchards (including Bananas), Vineyards and Forests–ring weeding around trees with brown bark and strip spraying in Orchards and Vineyards	2.4 to 3.2	No	68	No	411
(spot spray)	2.4 to 3.2	No	68	Yes	411
Hazelnut plantations	2.4 to 3.2	No	68	No	411
(spot spray)	2.4 to 3.2	No	68	Yes	411
Pistachio nuts	2.4 to 3.2	No	68	No	411
(spot spray)	2.4 to 3.2	No	68	Yes	411
Walnuts	2.4 to 3.2	No	68	No	411
(spot spray)	2.4 to 3.2	No	68	Yes	411
Pre-crop emergence weed control	2.4 to 3.2	Yes	800 (WOE)	No	251
(spot spray)	2.4 to 3.2	Yes	320 (WOE)	No	251
Long-term weed control	2.4 to 3.2	No	-[30]	No	-
(spot spray)	2.4 to 3.2	No	-	No	-
Potatoes weed control	2.4 to 3.2	Yes	800 (WOE)	No	251
(spot spray)	2.4 to 3.2	Yes	320 (WOE)	No	251
Potatoes weed destruction prior to digging	3.2	No	452	No	246
(spot spray)	3.2	Yes	452	No	246
Avocados, custard apples, lychees, mangoes (spot spray)	1.2 to 2.4	No	68	Yes	411

[30] The use situation for 'long term weed control' is not sufficiently well defined to identify the relevant risk assessment scenario(s) for terrestrial vertebrates. The risk is concluded to be unacceptable.

Crop/situation	Product rate range (L/ha)	Wild mammal assessment	Max rate supported (g acs/ha)	Bird assessment	Max rate supported (g acs/ha)
Rice	1.6 to 3.2	Yes	800 (WOE)	No	251
Pasture (Kikuyu/paspalum)	2.4 to 3.2	No	68	No	203
Pasture	0.8 to 2.4	No	68	No	203
Duboisia	2.4 to 3.2	No	68	No	411
Tea trees	1.6 to 3.2	No	68	No	411

WOE = weight-of-evidence, the risk assessment conclusion is based on a weight-of-evidence argument

Table 44: Screening level assessment of risks of combination products containing 115 g/L diquat and 135 g/L paraquat to bees

Life stage	Exposure	Rate (g/ha)	Predicted total dose (µg/bee)	RAL (µg/bee)	RQ
Screening level assessment (pollen & nectar EEC (mg/kg) = rate × 98 / 1000)					
Adults	Acute contact	800	1.9	10	0.19
	Acute oral	800	23	6.4	**3.6**
Refined assessment (pollen EEC (mg/kg) = rate × 52 / 1000 + nectar EEC (mg/kg) = rate × 11 / 1000)					
Adults	Acute oral	800	2.6	6.4	0.40

Screening level pollen and nectar EEC based on default RUD 98 mg/kg

Refined assessment based on 90th percentile RUD values of 52 mg/kg for pollen and 11 mg/kg for nectar from EFSA (2013b)

Predicted total dose calculated using USEPA BeeREX tool for adult worker bee foraging for nectar and larval drone within the hive

RAL = regulatory acceptable level from Table 40

RQ = risk quotient = PEC / RAC, where acceptable RQ ≤1

Table 45: Assessment of risks of combination products containing 115 g/L diquat and 135 g/L paraquat to other non-target arthropods

Group	Exposure	Scenario	Rate (g acs/ha)	RAL (g acs/ha)	RQ
Foliar arthropods	Contact	Worst-case	800	5.6	**143**

Group	Exposure	Scenario	Rate (g acs/ha)	RAL (g acs/ha)	RQ
		Best-case	150	5.6	**27**

RAL = regulatory acceptable level from Table 40

RQ = risk quotient = PEC / RAL, where acceptable RQ ≤1

6.6 Recommendations

Uses supported from the viewpoint of environmental safety are listed in Table 46 with the required protection statements and restraints. Uses that are not supported from the viewpoint of environmental safety are listed in Table 47.

Table 46: Supported uses from the viewpoint of environmental safety

Product type	Situation	Protection statements and restraints
n/a	All supported uses	DO NOT apply if heavy rains or storms are forecast within 3 days DO NOT irrigate to the point of field runoff for at least 3 days after application. Toxic to birds and native mammals. However, the use of this product as directed is not expected to have adverse effects on birds and native mammals. Very toxic to aquatic life. DO NOT contaminate wetlands or watercourses with this product or used containers. Toxic to beneficial arthropods. Not compatible with integrated pest management (IPM) programs utilising beneficial arthropods. Minimise spray drift to reduce harmful effects on beneficial arthropods in non-crop areas.
Paraquat only products	Aid to cultivation (crop, pasture or fallow establishment) at rates up to 231 g ac/ha Fallows at rates up to 770 g ac/ha for optical spot sprayers Firebreaks, non-agricultural situations (around sheds, roadways, paths), Peanuts at rates up to 231 g ac/ha Rice at rates up to 200 g ac/ha Spray topping to reduce annual ryegrass seed set (select pulses) 200 g ac/ha	No additional protection statements or restraints required
Combination products containing	Aid to cultivation (crop, pasture or fallow establishment) at rates up to 251 g acs/ha	No additional protection statements or restraints required

Product type	Situation	Protection statements and restraints
115 g/L diquat and 135 g/L paraquat[31]	Market gardens, pre-emergence weed control (vegetable crops) at rates up to 251 g acs/ha (Spot-spray only) Potatoes (early emergence general weed control) at rates up to 251 g acs/ha (Spot-spray only) Public service areas and rights of way	
Combination products containing paraquat and amitrole[32]	Aid to cultivation (crop, pasture or fallow establishment), fallow establishment and maintenance (boom sprayers) at rates up to 231 g ac/ha Fallow establishment and maintenance at rates up to 770 g ac/ha for optical spot sprayers Firebreaks, non-agricultural situations (around sheds, roadways, paths)	No additional protection statements or restraints required

Table 47: Uses not supported from the viewpoint of environmental safety

Product type	Situation	Basis
Paraquat only products	Sugarcane (directed interrow spray) at rates >103 g ac/ha; sugarcane (boomspray) at rates >137 g ac/ha; peanuts at rates >213 g ac/ha; Lucerne, potatoes at rates >226 g ac/ha; aid to cultivation (crop, pasture or fallow establishment), hops, market gardens, rice, row crops, vegetables at rates >231 g ac/ha; fallows (for optical spot sprayers) at rates >770 g ac/ha	Unacceptable risk to birds
	Bananas, hay freezing (grass pasture desiccation), orchards, pasture, perennial grass seed crops, prevention of annual rye grass toxicity, spray topping to reduce seed set (pastures), vineyards at rates >54 g ac/ha; potatoes at rates >363 g ac/ha	Unacceptable risk to mammals
	Hay freezing (grass pasture desiccation), pasture, perennial grass seed crops at rates >187 g ac/ha; bananas, orchards, vineyards at rates >377 g ac/ha; fallow at rates >675 g ac/ha	Unacceptable risk to birds and mammals

[31] Application rates reflect the total active substances (diquat and paraquat)

[32] Application rates reflect the paraquat content only

Product type	Situation	Basis
Combination products containing 115 g/L diquat and 135 g/L paraquat[33]	Sugarcane (boomspray and directed interrow spray) at rates >149 g acs/ha; Lucerne at rates >231 g acs/ha; potatoes (weed destruction prior to digging) at rates >246 g acs/ha; aid to cultivation (crop, pasture or fallow establishment; full and minimal disturbance), aid in post-harvest weed control (winter cereals), market gardens, nurseries, pre-crop emergence weed control (vegetable crops), potatoes (weed control), rice (pre-emergent use only), sugarcane (establishment and fallows prior to planting) at rates >251 g acs/ha	Unacceptable risk to birds
	Avocados, custard apples, duboisia, forests, grasses, hazelnut plantations, lychees, mangoes, orchards (including bananas), pasture, pistachio nuts, tea trees, vineyards, walnuts at rates >68 g acs/ha; cotton at rates >271 g acs/ha	Unacceptable risk to mammals
	Pasture, grasses at rates >203 g acs/ha; duboisia, forests, hazelnut plantations, orchards (including bananas), pistachio nuts, tea trees, vineyards, walnuts at rates >411 g acs/ha; potatoes (weed destruction prior to digging) at rates >452 g acs/ha Long term weed control[34]	Unacceptable risk to birds and mammals
Combination products containing paraquat and amitrole[35]	Potatoes (pre-harvest weed control) at rates >226 g ac/ha; aid to cultivation, fallow establishment and maintenance (boomspray) at rates >231 g ac/ha; fallow establishment and maintenance (optical spot sprayers) at rates >770 g ac/ha	Unacceptable risk to birds
	Hay freezing, orchards, pastures, spray topping to reduce seed set, vineyards at rates >54 g ac/ha	Unacceptable risk to mammals
	Potatoes (pre-harvest weed control) at rates >363 g ac/ha; orchards, vineyards at rates >377 g ac/ha	Unacceptable risk to birds and mammals

[33] Application rates reflect the total active substances (diquat and paraquat)

[34] The use situation for 'long term weed control' is not sufficiently well defined to identify the relevant risk assessment scenario(s) for terrestrial vertebrates. The risk is concluded to be unacceptable.

[35] Application rates reflect the paraquat content only

7 Spray drift

The APVMA's approach to spray drift management set out in the APVMA Spray Drift Policy July 2019 specifies consideration of spray drift in bystander areas, livestock areas, natural aquatic areas, pollinator areas and vegetation areas. The regulatory acceptable levels (RALs) for each area for paraquat as summarised in Table 48 define the maximum amount of spray drift exposure that is not expected to cause undue harm to sensitive areas.

Table 48: Regulatory acceptable levels of paraquat resulting from spray drift

Area considered	Regulatory acceptable level
Natural aquatic areas	0.15 µg ac/L
Pollinator areas	2667 g ac/ha
Vegetation areas	11 g ac/ha
Bystander areas	5.21 g ac/ha
Livestock areas	9.62 mg/kg

The APVMA has considered spray drift implications for uses of paraquat that are supported by worker health and safety, residues, trade and environmental risk assessments. These uses include:

- fallows establishment and aid to cultivation
- spray-topping to reduce seed set
- inter-row sprays in banana plantations
- general post-sowing, pre-crop-emergence weed control in rice.

The APVMA has also considered the spray drift risk resulting from combined toxicity of paraquat and diquat present in chemical products co-formulated with both active constituents. The regulatory acceptable levels of the co-formulated products, accounting for the combined toxicity of both paraquat and diquat are listed in Table 49.

Table 49: Regulatory acceptable levels of paraquat and diquat resulting from spray drift of chemical products co-formulated with both active constituents

Area considered	Regulatory acceptable level
Natural aquatic areas	1.0 µg ac/L
Pollinator areas	4333 g ac/ha
Vegetation areas	15 g ac/ha
Bystander areas	4.49 g ac/ha
Livestock areas	17.8 mg/kg

Uses of products that contain both paraquat and diquat which are supported by worker health and safety, residues, trade and environmental risk assessments are limited to fallows establishment and aid to cultivation at rates up to 251 g combined active constituents (acs) per hectare (251 g acs/ha).

Based on the acceptable uses the following spray drift restraints and downwind buffer zones would be required for application of paraquat products at the rates listed in Table 50 and for combination products containing paraquat and diquat in Table 51.

SPRAY DRIFT RESTRAINTS

Specific definitions for terms used in this section of the label can be found at apvma.gov.au/spraydrift.

DO NOT allow bystanders to come into contact with the spray cloud.

DO NOT apply in a manner that may cause an unacceptable impact to native vegetation, agricultural crops, landscaped gardens and aquaculture production, or cause contamination of plant or livestock commodities, outside the application site from spray drift. The advisory buffer zones in the relevant buffer zone table/s below provide guidance but may not be sufficient in all situations. Wherever possible, correctly use application equipment designed to reduce spray drift and apply when the wind direction is away from these sensitive areas.

DO NOT apply unless the wind speed is between 3 and 20 kilometres per hour at the application site during the time of application.

DO NOT apply if there are surface temperature inversion conditions present at the application site during the time of application. These conditions exist most evenings one to 2 hours before sunset and persist until one to 2 hours after sunrise.

DO NOT apply by a boom sprayer unless the following requirements are met:

- spray droplets not smaller than a MEDIUM spray droplet size category
- minimum distances between the application site and downwind sensitive areas (see 'Mandatory buffer zones' section of the following table titled 'Buffer zones for boom sprayers') are observed.

Table 50: Paraquat buffer zones for boom sprayers

Paraquat - buffer zones for boom sprayers						
Application rate	Boom height above the target canopy	Mandatory downwind buffer zones (metres)				
		Bystander areas	Natural aquatic areas	Pollinator areas	Vegetation areas	Livestock areas
200 g ac/ha or lower	0.5 m or lower	5	250	0	0	0
	1.0 m or lower	Not supported				
150 g ac/ha or lower	0.5 m or lower	0	160	0	0	0
	1.0 m or lower	Not supported				

Paraquat - buffer zones for boom sprayers						
Application rate	Boom height above the target canopy	Mandatory downwind buffer zones (metres)				
		Bystander areas	Natural aquatic areas	Pollinator areas	Vegetation areas	Livestock areas
100 g ac/ha or lower	0.5 m or lower	0	100	0	0	0
	1.0 m or lower	20	325	0	15	0

Table 51: Diquat/paraquat co-formulated product buffer zones for boom sprayers

Diquat-paraquat co-formulated chemical products – buffer zones for boom sprayers						
Application rate	Boom height above the target canopy	Mandatory downwind buffer zones (metres)				
		Bystander areas	Natural aquatic areas	Pollinator areas	Vegetation areas	Livestock areas
250 g acs/ha or lower	0.5 m or lower	10	40	0	0	0
	1.0 m or lower	50	120	0	20	0
200 g acs/ha or lower	0.5 m or lower	10	35	0	0	0
	1.0 m or lower	40	100	0	20	0
150 g acs/ha or lower	0.5 m or lower	5	30	0	0	0
	1.0 m or lower	30	80	0	15	0

7.1 Volatilisation

Volatilisation is the process by which a chemical converts from a liquid or solid state into a gas or vapor and moves away from the application site. This occurs after the chemical has been applied to plants, soil or other surfaces. Multiple factors contribute to the potential for a chemical to volatilise including the chemical's vapour pressure (the higher the vapour pressure the more volatile a chemical), the chemical's ability to bind strongly to soil preventing its volatilisation, its water solubility (the more water soluble a chemical, the less likely it is to volatilise) and environmental factors such as temperature and wind. In 2023 the APVMA received data indicating that the vapour pressure of paraquat is higher than initially reported (5.3×10^{-4} Pa versus 1×10^{-5} Pa) (Markell A, 2023).

Human health – Upon review of this information, the APVMA considers that risks to occupational users and bystanders due to potential paraquat volatilisation remains acceptable. This conclusion is based on the new vapour pressure value approximating the level at which chemicals are generally considered to be non-volatile in field conditions ($\leq 1.33 \times 10^{-4}$ Pa) (US EPA, 2025) and on the properties of paraquat that promote its strong adhesion to soil and high solubility in water, further limiting its potential for volatilisation.

> Environment – Paraquat is readily absorbed to and strongly bound to soil and as such volatilisation of residues applied to soil is not expected. Volatilisation from plant surfaces cannot be excluded based on the newly submitted information, however technical examination suggests further evaluation is not required. A screening assessment based on the UBA exposure model[36] indicates that for the uses currently supported (i.e. up to 231 g ac/ha, as per the terrestrial vertebrate risk assessment) the risk would be acceptable (for aquatic organisms and terrestrial non-target plants) when crop interception under realistic field conditions is considered.

In November 2025 the US EPA released an updated review of the potential for paraquat to volatise from treated agricultural fields (US EPA, 2025). Due to uncertainties regarding the possibility of paraquat volatilising to a higher degree than previously considered, the US EPA has issued a Data-Call In notice to paraquat manufacturers requesting additional data. The APVMA will continue to monitor additional data and regulatory outcomes on paraquat that are applicable to its use in Australia.

[36] https://www.bvl.bund.de/SharedDocs/Downloads/04_Pflanzenschutzmittel/zul_umwelt_eva_prog-EN.html?nn=11010942

8 Storage and disposal

The agricultural labelling code provides guidance on appropriate statements to ensure that storage of the chemical product and disposal of containers of the product or unused product does not pose an unacceptable risk to human health and the environment.

8.1 Storage

Schedule 7 Poisons require the following storage statement, including a direction to store the product in a locked room or place.

Store in a locked room or place away from children, animals, food, feedstuffs, seed and fertilisers. Store in the closed, original container in a cool, well-ventilated area. DO NOT store for prolonged periods in direct sunlight.

8.2 Disposal

Disposal statements are matched against the specification of the product and container. As the worker health and safety advised that the products should only be used through closed mixing and loading, containers suitable for closed mixing and loading would require the following disposal instructions:

Empty contents fully into application equipment. Close all valves and return to [point of supply/designated collection point/other specific collection details] for refill or storage.

Appendix

Appendix A – Summary of assessment outcomes

Table 52: Risk assessment outcomes for products containing paraquat

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[37]	Overall Outcome
Aid to cultivation; crop, pasture or fallow establishment	Annual grass and broadleaf weed control (winter, spring and early summer sowing)	400-600 g ac/ha (boomspray)	Not supported (max. 231 g ac/ha)	Supported	Supported	Not supported
	Annual grass and broadleaf weed control (early Autumn sowing)	300-400 g ac/ha (boomspray)		Supported	Supported	Not supported
	Volunteer canola including Roundup Ready varieties (4-6 leaf stage)	450-600 g ac/ha (boomspray)		Supported	Supported	Not supported
	Wild oats at 2-5 leaf stage (autumn/winter)	150-200 g ac/ha (boomspray)	Supported	Supported	Supported	Supported
	Wild oats at 2-5 leaf stage (spring/summer)	300-500 g ac/ha (boomspray)	Not supported (max. 231 g ac/ha)	Supported	Supported	Not supported
Bananas	Annual grasses and broadleaf weeds	396-1120 g ac/ha (Spot spray [448 g ac/ha])	Not supported (max. 54 g ac/ha)	Supported	Supported **DO NOT** apply by spraying equipment carried on the back of the user.	Not supported
Bananas	Annual grasses and broadleaf weeds	250-810 g ac/ha (Inter-row boomspray [324 g ac/ha])	Not supported (max. 54 g ac/ha)	Supported	Supported	Not supported

[37] See Table 10 in Paraquat Final Review Technical Report for PPE and work rate restrictions

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[37]	Overall Outcome
Fallows	barnyard grass, bladder ketmia, yellow vine (caltrop)	750-2250 g ac/ha (Optical spot spray)	Up to 770 g ac/ha (231 g ac/ha based on 30% area treated) (changed from PRD)	Supported	Supported	Supported[38] (changed from PRD)
	fleabane, sowthistle, turnip weed,	1500-2250 g ac/ha (Optical spot spray)	Not supported (max. 770 g ac/ha [231 g ac/ha based on 30% area treated])	Supported	Supported	Not supported
	Australian bindweed	2250 g ac/ha (Optical spot spray)	Not supported (max. 770 g ac/ha [231 g ac/ha based on 30% area treated])	Supported	Supported	Not supported
Summer Fallow Volunteer cotton & ratoon cotton (Gossypium hirsutum) Including Roundup Ready Flex* varieties	Summer Fallow Volunteer cotton & ratoon cotton (Gossypium hirsutum) Including Roundup Ready Flex* varieties	800 g ac/ha (Optical spot spray)	Not supported (max. 770 g ac/ha [231 g ac/ha based on 30% area treated])	Supported	Supported	Not supported
Firebreaks	Annual grasses and broadleaf weeds	390-1020 g ac/ha (Boomspray)	Supported *WoE (changed from PRD) (changed from PRD)	Supported	Supported	Supported (changed from PRD)
	Knock down weed growth to eliminate fire hazard or assist firebreak burn.			Supported	Supported	Supported

[38] Note only lower rates of range supported

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[37]	Overall Outcome
Hay freezing (grass pasture desiccation)	Maximum retention of protein in standing dry feed	200 g ac/ha (Boomspray)	Not supported (max. 54 g ac/ha)	Supported	Supported	Not supported
Hops	Annual grasses and broadleaf weeds	300-400 g ac/ha (Inter-row spray)	Not supported (max. 231 g ac/ha)	Supported	Supported	Not supported
Lucerne (Autumn / early winter)	Annual grass and some broadleaf weeds	300-420 g ac/ha (Boomspray)	Not supported (max. 226 g ac/ha)	Supported	Supported	Not supported
Lucerne (late winter / early spring)	Annual grass and some broadleaf weeds	300-600 g ac/ha (Boomspray)	Not supported (max. 226 g ac/ha)	Supported	Supported	Not supported
Non-agricultural situations (around sheds, roadways, paths)	Annual grasses and broadleaf weeds, columbus grass	400-1125 g ac/ha (Boomspray, spot spray)	Supported *WoE (changed from PRD)	Supported	Supported	Supported (changed from PRD)
	Annual grasses and broadleaf weeds			Supported (noting change to crop-group descriptors)		Not supported
Orchards (including walnuts), Vineyards	Annual weed control	400-800 g ac/ha (Spot spray, inter-row spray)	Not supported (max. 54 g ac/ha)	Supported (noting change to crop-group descriptors)	Supported	Not supported
	Annual grasses and broadleaf weeds / annual weed control			Supported (noting change to crop-group descriptors)		Not supported
Pasture (Kikuyu/paspalum)	To suppress growth to oversow winter seed	400-600 g ac/ha (Boomspray)	Not supported (max. 54 g ac/ha)	Supported	Supported	Not supported

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[37]	Overall Outcome
Pastures (pasture cleaning in autumn / winter / early spring - annual and perennial clovers, cocksfoot, perennial ryegrass, Phalaris, Demeter fescue only)	Annual grass and some broadleaf weed control except Paterson's Curse, Sorrel, Dock, Shepherd's Purse and some thistles	150-600 g ac/ha (Boomspray)	Not supported (max. 54 g ac/ha)	Supported	Supported	Not supported
	Yorkshire fog grass	300 g ac/ha (Boomspray)		Supported	Supported	Not supported
Peanuts	Annual ground cherry (2-3 leaf), Apple-of-Peru (2-4 leaf), Milkweed (2-3 leaf)	150 g ac/ha (Boomspray)	Supported	Supported	Supported	Supported
	Datura spp. (2-4 leaf)	100 g ac/ha (Boomspray)		Supported	Supported	Supported
	Stagger weed (2-3 leaf), Blue heliotrope (2-3 leaf), Wandering Jew (2-3 leaf), Anoda weed (2-4 leaf)	200 g ac/ha (Boomspray)		Supported	Supported	Supported
	Bellvine (2-3 leaf), Common morning glory (2 leaf)	250 g ac/ha (Boomspray)	Not supported (max. 213 g ac/ha)	Supported	Supported	Not supported
Perennial Grass, Seed crops (cocksfoot, perennial ryegrass, phalaris and Demeter Fescue only)	Annual grass and some broadleaf weeds	150-300 g ac/ha (Boomspray)	Not supported (max. 54 g ac/ha)	Supported	Supported	Not supported

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[37]	Overall Outcome
Potatoes	Annual grasses and broadleaf weeds (Early crop no later than 25% emergence of shoots)	300-400 g ac/ha (Boomspray)	Not supported (max. 226 g ac/ha)	Supported	Supported	Not supported
	Annual grasses and broadleaf weeds (pre-harvest weed control)	700 g ac/ha (Boomspray)	Not supported (max. 226 g ac/ha)	Supported (4-5 weeks before digging)	Supported	Not supported
Prevention of annual ryegrass toxicity	Annual ryegrass. Spray top, graze to destroy seed heads	100 g ac/ha (Boomspray)	Not supported (max. 54 g ac/ha)	Supported	Supported	Not supported
Rice	Pre-sowing annual grass and broadleaf weed control	400 g ac/ha (Boomspray)	Not supported (max. 231 g ac/ha)	Supported	Supported	Not supported
	Post-sowing, pre-crop emergence annual grass and broadleaf weed control	200 g ac/ha (Boomspray)	Supported	Supported	Supported	Supported
Row crops, vegetables, market gardens	Pre-planting and pre-crop emergence	300-420 g ac/ha (Boomspray)	Not supported (max. 231 g ac/ha)	Supported	Supported	Not supported
	Post-emergence inter-row weed control	300-420 g ac/ha (Inter-row spray)	Not supported (max. 231 g ac/ha)	Supported	Supported	Not supported
	Older weeds	600 g ac/ha (Inter-row spray)	Not supported (max. 231 g ac/ha)	Supported	Supported	Not supported

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[37]	Overall Outcome
Spray topping to reduce seed set (Field peas, Lupins, Lentils, Chickpeas, Faba Beans)[39]	Annual ryegrass	100-200 g ac/ha (Boomspray)	Supported (changed from PRD)	Supported (vary WHP to 14 days)	Supported	Supported (changed from PRD)
Spray topping to reduce seed set (pastures)	Grasses generally (particularly annual ryegrass)	100-200 g ac/ha (Boomspray)	Not supported (max 54 g ac/ha)	Supported	Supported	Not supported
	Saffron thistle			Supported	Supported	Not supported
Sugarcane (plant and ratoon)	Grasses and some broadleaf weeds	300-400 g ac/ha (Boomspray)	Not supported (max. 137 g ac/ha)	Supported	Supported	Not supported
		300-400 g ac/ha (Directed interrow spray – droppers/shields/leaf deflectors)	Not supported (max. 103 g ac/ha)	Supported	Supported	Not supported

Table 53: Risk assessment outcomes for products containing paraquat and diquat

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
Aid to cultivation (Southern Australia - full disturbance)	Seedling Grasses: Annual Ryegrass *(Lolium*	2-3 leaf: 150-200 g acs/ha (Boomspray)	Supported	Supported	Supported	Supported[41]

[39] Spray topping in vetch is not supported although these uses are grouped on current labels, as it is a pasture legume rather than a pulse

[40] See Table 11 in Diquat Final Review Technical Report for PPE and work rate restrictions

[41] Note only lower rates of range supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
	rigidum), Barley Grass *(Hordeum spp.)*, Brome Grass *(Bromus spp.)*, Volunteer Cereals, Wild Oats *(Avena spp.)*	4 leaf to early tiller: 200-400 g acs/ha (Boomspray)	Supported (max. 251 g acs/ha)	Supported	Supported	Supported[41]
		Mid to fully tillered: 400-600 g acs/ha (Boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not supported
	Vulpia (Silver Grass, Sand Fescue) *(Vulpia spp.)*	2-3 leaf: 150-200 g acs/ha (Boomspray)	Supported up to 251 g acs/ha)	Supported	Supported	Supported[41]
		4 leaf to early tiller: 200-400 g acs/ha (Boomspray)	Supported (max. 251 g acs/ha)			Supported[41]
		Mid to fully tillered: 400-600 g acs/ha (Boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not Supported
	Seedling Brassica Weeds	1-5 cm diameter: 200-300 g acs/ha (boomspray)	Supported (max. 251 g acs/ha)	Supported	Supported	Supported[41]
		5-10 cm diameter: 300-400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not Supported
		10-20 cm diameter: 400-600 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not Supported
	Other Seedling Broadleaved Weeds	1 to 4 leaf or 1 to 4 cm diameter: 200-300 g acs/ha (boomspray)	Supported (max. 251 g acs/ha) Supported up to 251 g acs/ha	Supported	Supported	Supported[41]

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
		4-8 leaf or 4-8 cm diameter: 300-400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not Supported
	Deadnettle *(Lamium amplexicaule)*, Fumitory *(Fumitory spp.)*, Melilotus *(Melilotus spp.)*, Pimpernel *(Anagallis spp.)*, Poppy *(Papaver spp.)*, Saffron Thistle *(Carthmus lanatus)*, Sheepweed *(Buglossoides arvensis)*	1 to 10 leaf or 1 to 10 cm diameter: 200-300 g acs/ha (boomspray)	Supported (max. 251 g acs/ha)	Supported	Supported	Supported[41]
	Paterson's curse *(Echium plantagineum)*	1 to 5 leaf: 300-400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not Supported
	Wireweed *(Polygonum aviculare)*	1 to 4 leaf: 200-300 g acs/ha (boomspray)	Supported (max. 251 g acs/ha)	Supported	Supported	Supported[41]
	Marshmallow *(Malva parviflora)*	1 to 12 leaf: 200-300 g acs/ha plus Oxyfluorfen 75 mL/ha	Supported up to 251 g acs/ha)	Supported	Supported	Supported[41]
	Volunteer Beans, Peas & Lupins	1 to 6 leaf: 200-300 g acs/ha plus Metsun 5 g/ha or Dicamba 100 g ac/ha.	Supported up to 251 g acs/ha)	Supported	Supported	Supported[41]

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
Aid to cultivation (Southern Australia - fallow/minimum disturbance)	Seedling Grasses: Annual Ryegrass *(Lolium rigidum)*, Barley Grass *(Hordeum spp.)*, Brome Grass *(Bromus spp.)*, Volunteer Cereals, Wild Oats *(Avena spp.)*	2-3 leaf: 250-300 g acs/ha (Boomspray)	Supported (max. 251g acs/ha)	Supported	Supported	Supported[41]
		4 leaf to early tiller: 300-600 g acs/ha (Boomspray)	Not supported (max. 251g acs/ha)	Supported	Supported	Not supported
		Mid to fully tillered: 600-800 g acs/ha (Boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not supported
	Vulpia (Silver Grass, Sand Fescue) *(Vulpia spp.)*	2-3 leaf: 250-300 g acs/ha (Boomspray)	Supported (max. 251 g acs/ha)	Supported	Supported	Supported[41]
		4 leaf to early tiller: 300-600 g acs/ha (Boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not supported
		Mid to fully tillered: 600-800 g acs/ha (Boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not supported
	Seedling Brassica Weeds	1-5 cm diameter: 300-450 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha)	Supported	Supported	Not supported
		5-10 cm diameter: 450-600 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha			
		10-20 cm diameter: 600-800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha			

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
	Other Seedling Broadleaved Weeds	1 to 4 leaf or 1 to 4 cm diameter: 300-450 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
		4-8 leaf or 4-8 cm diameter: 450-800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha		Supported	
	Deadnettle *(Lamium amplexicaule)*, Fumitory *(Fumitory spp.)*, Melilotus *(Melilotus spp.)*, Pimpernel *(Anagallis spp.)*, Poppy *(Papaver spp.)*, Saffron Thistle *(Carthmus lanatus)*, Sheepweed *(Buglossoides arvensis)*	1 to 10 leaf or 1 to 10 cm diameter: 300-800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Paterson's curse *(Echium plantagineum)*	1 to 5 leaf 450-800 g acs/ha (boomspray)	Not supported (max. 225 g acs/ha	Supported	Supported	Not supported
	Wireweed *(Polygonum aviculare)*	1 to 4 leaf: 300-800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Marshmallow *(Malva parviflora)*	1 to 12 leaf: 300-450 g acs/ha plus Oxyfluorfen 75 mL/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
	Volunteer Beans, Peas & Lupins	1 to 6 leaf: 300-450 g acs/ha plus Metsun 5g g/ha or Dicamba 100 g ac/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Medic *(Medicago spp.)*, Sub-Clover *(Trifolium subterraneum)*	1 to 4 leaf or 1 to 4 cm diameter: 300-450 g acs/ha plus Metsun 5 g/ha or Dicamba 100 g ac/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Medic *(Medicago spp.)*, Sub-Clover *(Trifolium subterraneum)*	4 to 8 leaf or 4 to 8 cm diameter: 300-450 g acs/ha plus Dicamba 100 g ac/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Split application for: Sub-Clover (*Trifolium subterraneum)* Perennial Ryegrass *(Lolium perenne)* Most Annual Weeds	1 to 8 leaf: 2 times 300 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Split application for: Sub-Clover (*Trifolium subterraneum)* Perennial Ryegrass *(Lolium perenne)* Most Annual Weeds	4 leaf to early tiller: 2 times 300 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Split application for: Sub-Clover (*Trifolium subterraneum)* Perennial Ryegrass *(Lolium perenne)* Most Annual Weeds	Mid to fully tillered: 2 times 400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Split application for: Sub-Clover (*Trifolium subterraneum)* Perennial Ryegrass *(Lolium perenne)* Most Annual Weeds	Weeds higher than 10cm: 600 to 800 g acs/ha in two applications (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
	Potato Weed *(Heliotropium europaeum)*	1 to 15 cm: 300 to 400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
		15 to 30 cm: 400-600 g acs/ha (boomspray)				
Aid to cultivation (Northern Australia - full disturbance)	Seedling Grasses	2 to 3 leaf: 200-300 g acs/ha (boomspray)	Supported up to 251 g acs/ha	Supported	Supported	Supported[41]
		4 leaf to early tiller: 300-400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
		Mid to fully tillered: 400-800 g ac/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Sorghum *(Sorghum bicolour)*, Stink Grass *(Eragrostis cilianensis)*	2-3 leaf only: 200-300 g ac/ha (boomspray)	Supported up to 251 g acs/ha	Supported	Supported	Supported[41]
	Seedling Broadleaved Weeds	1 to 4 leaf: 200-400 g acs/ha (boomspray)	Supported up to 251 g acs/ha	Supported	Supported	Supported[41]
		4 to 8 leaf: 400-800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
		8 to 12 leaf: 800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Native Jute *(Corchorus trilocularis)*	1 to 8 leaf: 300-400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
	Annual Ground Cherry (*Physalis angulata*), Turnip Weed *(Rapistrum rugosum)*	1 to 4 leaf: 300-400 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Boggabri *(Amaranthus mitchellii)*, Hexham Scent *(Melilotus indicus)*, Wild Carrot *(Daucus glochidiatus)*, Speedy Weed *(Flaveria australasica)*	1 to 8 leaf: 200-300 g acs/ha (boomspray)	Supported up to 251 g acs/ha	Supported	Supported	Supported[41]
Aid to cultivation (Northern Australia - fallow/minimum disturbance)####	Seedling Grasses	300-800 g ac/ha (Boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
	Seedling Broadleaved Weeds			Supported	Supported	Not supported
	Volunteer Cotton (including Roundup® Ready Cotton) *(Gossypium hirsulum)*			Supported	Supported	Not supported
	Boggabri *(Amaranthus mitchellii)*, Hexham Scent *(Melilotus indicus)*, Wild Carrot *(Daucus glodcidiatus)*, Phyllanthus *(Phyllanthus spp.)*			Supported	Supported	Not supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
Aid in Post-Harvest weed control (Nothern Australia – after Winter Cereals)	Volunteer Barley *(Hordeum vulgare)*, Volunteer Wheat *(Triticum aestivum)*, Bladder Ketmia *(Hibiscus trionum)*, Milk Thistle *(Sonchus oleraceus)*, New Zealand Spinach *(Tetragonia tetragonioides)*	400-600 g ac/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported
Sugarcane - establishment and fallows prior to planting	Seedling Grasses: (not regrowth or rhizomes) Barnyard Grass (*Echinochloa spp.)*, Liverseed Grass *(Urochloa panicoides)*, Stink Grass *(Eragrostis cilianensis)*	300-800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha)	Supported	Not supported	Not supported
	Seedling Broadleaved Weed			Supported	Supported	Not supported
	Seedling Phyllanthus *(Phylanthus spp.)*			Supported	Supported	Not supported
	Mature grasses, broadleaf weeds and Phyllanthus (*Phylanthus spp.*)	800 g ac/ha (boomspray)	Not supported (max. 251 g acs/ha	Supported	Supported	Not supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
Sugarcane - plant and ratoon	Most Seedling Broadleaf Weeds including Sicklepod *(Senna (Cassia) obtusifolia)*, Bluetop *(Ageratum houstonianum)*, Phyllanthus *(Phyllanthus spp.)*, Calopo *(Calapogonium muconoides)*	300-700 g acs/ha (boomspray or directed interrow spray)	Not supported (max. 149 g acs/ha)	Supported	Supported	Not supported
	Most Seedling Grasses including Awnless Barnyard Grass *(Echinochloa colona)*, Summer Grass *(Digitaria ciliaris)*,Guinea Grass *(Panicum maximum)*,Hamil Grass *(Panicum maximum cv Hamil)*,Green Summer Grass *(Brachiaria miliiformis)*			Supported	Supported	Not supported
Cotton	Desiccant to aid harvest	300-400 g acs/ha (boomspray)	Not supported (max. 271 g acs/ha)	Supported	Supported	Not supported
Lucerne (established at least 1 year old)	Most annual weeds including Capeweed and Erodium. For improved grazing, hay or seed production or over sowing, enhanced control of some broadleaf weeds, and short term residual weed control.	400-600 g acs/ha (boomspray)	Not supported (max. 231 g acs/ha)	Supported	Supported	Not supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome [40]	Overall Outcome
Public Service Areas, Rights-of-Way, Market Gardens and Nurseries, Orchards (including Bananas), Vineyards and Forests - ring weeding around trees with brown bark and strip spraying in Orchards and Vineyards	Most Annual Grasses and Broadleaved Weeds Weed control prior to crop emergence	600-800 g acs/ha (High Volume or Power Sprayer, spot spray)	Supported for public Service Areas, and Rights-of-Way	Supported	Supported (NOT for backpack sprayer)	Supported
			Spot spray only supported Market gardens and nurseries (max. 251 g acs/ha)	Supported	Supported (NOT for backpack sprayer)	**Spot spray only supported**
			Not supported Orchards (including bananas), vineyards. (max. 68 g acs/ha)	Supported	Supported (NOT for backpack sprayer)	Not supported
Vegetable crops	Weed control prior to crop emergence - most Annual Grasses and Broadleaved Weeds	600-800 g acs/ha (High Volume or Power Sprayer, spot spray)	**Spot spray only supported** (max. 251 g acs/ha)	Supported	Supported	**Spot spray only supported**
Potatoes (10-25% crop emergence)	General weed control - most Annual Grasses and Broadleaved Weeds	600-800 g acs/ha (High Volume or Power Sprayer)	**Spot spray only supported** (max. 251 g acs/ha)	Supported	Supported	**Spot spray only supported**
Potatoes	Weed destruction prior to digging - most Annual Grasses and Broadleaved Weeds	800 g acs/ha (High Volume or Power Sprayer, spot spray)	Not supported (max. 246 g acs/ha)	Supported 4-5 week WHP	Supported	Not supported
Avocados, Custard Apples, Lychees, Mangoes	Most Annual and Perennial Broadleaf Weeds and Grasses	300-600g acs/ha (High Volume or Power Sprayer)	Not supported (max. 68 g acs/ha)	Supported	Supported	Not supported

Crop/situation	Weeds Controlled / Use	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome[40]	Overall Outcome
Rice (pre-emergent use only)	Annual Weeds including Barnyard Grass (on rice stubble after burning)	400-800 g acs/ha (boomspray)	Not supported (max. 251 g acs/ha)	Supported	Not supported	Not supported
	Clover control			Supported	Not supported	Not supported
	Annual Pasture - not properly managed			Supported	Not supported	Not supported
Pasture (Kikuyu/paspalum)	To suppress growth to oversow winter feed	600-800 g acs/ha (boomspray)	Not supported (max. 68 g acs/ha)	Supported	Not supported	Not supported
Pasture (Established - Perennial Grass Crops, Cocksfoot, Perennial Ryegrass, Phalaris and Demeter Fescue)	Control of annual weeds including: capeweed and erodium for improved grazing, hay or seed production.	400-600 g acs/ha (boomspray)	Not supported (max. 68 g acs/ha)	Supported	Supported	Not supported
Pasture (Improvement)	To increase the perennial grass and/or the sub-clover or white clover content	300 g acs/ha (boomspray)	Not supported (max. 68 g acs/ha)	Supported	Supported	Not supported
Grasses (particularly Annual Ryegrass)	To control grass seed set (Spray Top technique)	200-375 g acs/ha (boomspray)	Not supported (max. 68 g acs/ha)	Supported	Supported	Not supported
Duboisia	Annual weeds	600-800 g acs/ha (Directed spray)	Not supported (max. 68 g acs/ha)	Supported	Supported	Not supported
		600-800 g acs/ha (Spot Spray)	Not supported (max. 68 g acs/ha)	Supported	Supported	Not supported
Tea Trees *(Melaleuca alternifolia)*	Grasses and broadleaf weeds	400-800 g acs/ha (boomspray)	Not supported (max. 68 g acs/ha)	Supported	Not supported	Not supported

Appendix B – Listing of environmental endpoints

Table 54: Paraquat – Dissipation in animal food items

Substance	Matrix	Result	Reference
Paraquat	Insects	Beetles: DT_{50} 4.1 d Spiders: DT_{50} 4.6 d	Bakker 2005a
		Spiders: DT_{50} 3.5 d Lepidoptera: DT_{50} 3.5 d	Bakker 2005b
		Geomean DT_{50} 3.9 d	

Table 55: Paraquat – Fate and behaviour in soil

Substance	Study	Result	Reference
Paraquat	Soil photolysis	Stable	Pack 1982
	Biodegradability	Intrinsically biodegradable in soil pore water	Kuet et al, 2001, Ricketts 1999
	Aerobic laboratory soil	Sandy loam: stable <0.1% mineralisation after 180 d 0.7% bound residues after 180 d	Vickers et al, 1989a
	Anaerobic laboratory soil	Sandy loam: stable <0.1% mineralisation after 90 d 0.75% bound residues after 90 d	Vickers et al, 1989b
	Adsorption/ desorption	Soil / % clay / Kd (mL/g) Loam 21 50000 Loamy sand 8 5900 Silty clay loam 29 9400 Sand 2 480	Robbins et al, 1988
		$\log_{10}$ Kd = (1.32 × $\log_{10}$ % clay) + 2.84 at the SAC-WB concentration of the soil, based on data from 242 soils	Dyson et al, 1994
		Soil / % clay / Kf (µL/g) / 1/n 1 46 787 0.247 2 33 844 0.274 3 59 709 0.261 4 67 513 0.281 5 49 868 0.193 6 8.7 17.9 0.412 7 31 337 0.328 8 29 1095 0.204	Amondham et al, 2006

Substance	Study	Result		Reference
Paraquat	Terrestrial field dissipation	AU-Western Australia	DT_{50} >10 years	Muller & Roy 1997
		US-North Carolina	DT_{50} >10 years	Anderson et al, 1992(a), Dyson et al, 1995(a), 1995(b)
		US-California	DT_{50} >10 years	Anderson et al, 1992(b)
		US-Illinois	DT_{50} >10 years	Anderson et al, 1992(c)
		US-Mississipi	DT_{50} >10 years	Anderson et al, 1992(d)
		US-Delaware	DT_{50} >10 years	Earl et al, 1989
		UK-Frenshem	DT_{50} 20 years	Dyson & Chapman 1995
		UK-Yarnton	DT_{50} 6.6 years	Hance et al, 1980
		Malaysia	DT_{50} >10 years	Lane & Ngim 2000
		Thailand	DT_{50} 41 days	Amondham et al, 2006

Table 56: Paraquat – Fate and behaviour in water and sediment

Substance	Study	Result	Reference
Paraquat	Hydrolysis	pH 4, 50°C: stable pH 7, 50°C: stable pH 10, 50°C: stable	White 2010
		pH 5, 25°C: stable pH 7, 25°C: stable pH 9, 25°C: stable pH 5, 40°C: stable pH 7, 40°C: stable pH 9, 40°C: stable	Upton et al, 1985
	Aqueous photolysis	Stable (pH 7 buffer)	Parker & Leahey 1988
		Stable (natural river water)	Dean 2000
	Degradation in water/sediment	2systems: Virginia Water, Old Basing Max 91% paraquat in sediment (time 0) Stable in sediment <0.1% mineralisation after 100d 4.2-4.5% bound residues after 100d	Long et al, 1996

Table 57: Paraquat – Fate and behaviour in air

Substance	Study	Result	Reference
Paraquat	Photochemical oxidative degradation	DT_{50} 6.0 h	Hayes 2006

Table 58: Paraquat – Monitoring data

Substance	Medium	Result	Reference
Paraquat	Vegetation	No detectable uptake of paraquat residues from soil into the grain of wheat, corn or soybeans following annual applications of 1 kg ac/ha or one application up to 114 kg ac/ha	Dyson et al, 1995

Substance	Medium	Result	Reference
Paraquat	Soil	Max 4.7 mg/kg in 10 soils following cumulative exposure up to 13 kg ac/ha after 10 years	Stevens et al, 1988
		Max 3.3 mg/kg in 31 soils following cumulative exposure up to 50 kg ac/ha over many years. One soil contained 38 mg/kg following cumulative exposure of 24 kg ac/ha.	Stevens & Bewick 1991
		<40% residue decline was observed within 6 years of treatments ranging 0-120% SAC-WB in 3 soils (SAC-WB 65, 80 and 300 mg/kg)	Lane et al, 1992, Lane & Bouwman 2000
	Water	No detectable residues in water from a furrow irrigation system following application of SL 276 g/L formulation in sweet corn up to 1725 g ac/ha	Evans 2006

Table 59: Paraquat – Laboratory studies on terrestrial vertebrates

Substance	Group	Exposure	Species	Toxicity value[42]	Reference
Paraquat	Mammals	Acute	*Rattus norvegicus*	LD_{50} 103 mg ac/kg bw	Duerden 1994
				LD_{50} 105 mg ac/kg bw	Kimbrough & Gaines 1970
				LD_{50} 126 mg ac/kg bw	Murray & Gibson 1972
			Geomean LD_{50} 111 mg ac/kg bw		
			Mus musculus	LD_{50} 102 mg ac/kg bw	Fletcher 1967
				LD_{50} 166 mg ac/kg bw	Heylings & Farnworth 1992
				LD_{50} 203 mg ac/kg bw	Heylings & Farnworth 1992
			Geomean LD_{50} 151 mg ac/kg bw		
			Cavia porcellus	LD_{50} 22 mg ac/kg bw	Murray & Gibson 1972
			Oryctolagus cuniculus	LD_{50} 45 mg ac/kg bw	Farnworth et al, 1993
			Macaca fascicularis	LD_{50} 50 mg ac/kg bw	Murray & Gibson 1972
			Geomean LD_{50} 61 mg ac/kg bw (5 mammal species)		
		Chronic	*Rattus norvegicus*	NOAEL 7.2 mg ac/kg bw/d	Igarashi 1980
				NOAEL 3.8 mg ac/kg bw/d	Lindsay 1982(a),1982(b)
	Birds	Acute	*Anas platyrhynchos*	LD_{50} 54 mg ac/kg bw	Johnson 1998
			Colinus virginianus	LD_{50} 124 mg ac/kg bw	Fink et al, 1979
			Taeniopygia guttata	LD_{50} 27 mg ac/kg bw	Hubbard et al, 2014
			Geomean LD_{50} 57 mg ac/kg bw (3 bird species)		
		Dietary	*Anas platyrhynchos*	LC_{50} 2920 mg ac/kg feed	Hill et al, 1975
			Colinus virginianus	LC_{50} 706 mg ac/kg feed	Hill et al, 1975
			Coturnix coturnix	LC_{50} 698 mg ac/kg feed	Hill et al, 1975
			Phasianus colchicus	LC_{50} 1060 mg ac/kg feed	Hill et al, 1975
		Chronic	*Anas platyrhynchos*	NOAEL 2.7 mg ac/kg bw/d	Fink et al, 1982(a)

[42] All toxicity values are reported in terms of the active constituent which is defined as the paraquat cation. Dietary endpoints in mg ac/kg feed were converted to mg ac/kg bw/d using a default conversion factor (0.1) when food consumption data were not available

Table 60: Paraquat – Monitoring data on terrestrial vertebrates

Substance	Crop	Exposure	Effect	Reference
Paraquat	Various	Various	Deaths attributed to paraquat include 1 hedgehog, 1 hare and no birds in UK (1990-94); no vertebrate deaths attributed to paraquat in France (1994-95) or the Netherlands (1990-94)	de Snoo et al, 1999
			Hare deaths attributed to paraquat were 2/104 in UK (1974-97) and 8/13588 in France (1986-96)	Edwards et al, 2000
			Hare deaths attributed to paraquat were 3/112 in UK (1974-2002) and 9/21999 in France (1986-99); no deaths were attributed to paraquat in 216 bird and 8 mammal deaths in the Netherlands (1990-94)	Sutton et al, 2004

Table 61: Paraquat – Effects on aquatic species

Substance	Group	Exposure	Species	Toxicity value	Reference
Paraquat	Fish	Acute	*Oncorhynchus mykiss*	LC_{50} 19 mg ac/L	Tapp et al, 1990(a)
				LC_{50} 18 mg ac/L	Tapp et al, 1990(b)
				LC_{50} >33 mg ac/L	Scheerbaum 2007(a)
			Cyprinodon variegatus	LC_{50} >41 mg ac/L	Claude et al, 2014(a)
			Pimephales promelas	LC_{50} 4.7 mg ac/L	Claude et al, 2014(b)
			Cyprinus carpio	LC_{50} 98 mg ac/L	Tapp et al, 1990(c)
		Chronic	*Pimephales promelas*	NOEC 0.74 mg ac/L	Claude et al, 2014(c)
			Cyprinodon variegatus	NOEC 1.8 mg ac/L	Claude et al, 2014(d)
			Oncorhynchus mykiss	NOEC 8.5 mg ac/L	Tapp et al, 1990(d)
	Invertebrates	Acute	*Daphnia magna*	EC_{50} 4.4 mg ac/L	Allison & Hamer 1990
				EC_{50} 4.3 mg ac/L	Noack 2007
			Geomean EC_{50} 4.3 mg ac/L		
			Americamysis bahia	LC_{50} 0.23 mg ac/L	Claude et al, 2014(e)
			Crassostrea virginica	EC_{50} 23 mg ac/L	Claude et al, 2014(f)
		Chronic	*Daphnia magna*	NOEC 0.097 mg ac/L	Claude et al, 2014(g)
			Americamysis bahia	NOEC 0.038 mg ac/L	Claude et al, 2014(h)
	Sediment-dwellers	Acute	*Hyalella azteca*	LC_{50} 39 mg ac/kg ds	Bradley 2015(a)
			Leptocheirus plumulosus	LC_{50} >100 mg ac/kg ds	Bradley 2015(b)
			Chironomus dilutus	LC_{50} >100 mg ac/kg ds	Bradley 2015(c)
		Chronic	*Chironomus riparius*	NOEC 0.37 mg ac/L	Hamer & Ashwell 1997
				NOEC 100 mg ac/kg ds	Hamer 1998

Substance	Group	Exposure	Species	Toxicity value	Reference
Paraquat	Algae	Chronic	*Navicula pelliculosa*	E_rC_{50} 0.00034 mg ac/L	Smyth et al, 1992(b)
			Anabaena flos-aquae	EC_{50} 0.0078 mg ac/L	Smyth et al, 1992(c)
			Chlamydomonas reinhardtii	E_rC_{50} 0.043 mg ac/L	Cheloni & Slaveykova 2021
				E_rC_{50} 0.048 mg ac/L	Jamers & de Coen 2010
			Geomean E_rC_{50} 0.045 mg ac/L		
		Chronic	*Raphidocelis subcapitata*	E_rC_{50} 0.20 mg ac/L	Smyth et al 1990a
				E_rC_{50} 0.23 mg ac/L	Smyth et al, 1992(a)
				E_rC_{50} 0.20 mg ac/L	Scheerbaum 2007(b)
				E_rC_{50} 0.26 mg ac/L	Smyth et al, 1990(b)
			Geomean E_rC_{50} 0.22 mg ac/L		
			Chlorella vulgaris	E_rC_{50} 0.53 mg ac/L	Baltazar et al, 2014
			Skeletonema costatum	E_rC_{50} 5.9 mg ac/L	Smyth et al, 1992(d)
	Aquatic plants	Chronic	*Lemna minor*	E_rC_{50} 0.015 mg ac/L	Tagun & Boxall 2018
			Lemna gibba	E_rC_{50} 0.031 mg ac/L	Mohammad et al, 2010
				EC_{50} 0.037 mg ac/L E_rC_{50} 0.047 mg ac/L	Smyth et al, 1992e
			Geomean E_rC_{50} 0.038 mg ac/L		

Table 62: Paraquat – Effects on bees

Substance	Species	Life stage	Exposure	Toxicity value	Reference
Paraquat	*Apis mellifera*	Adult	Acute contact	LD_{50} 82 µg ac/bee	Bull & Wilkinson 1987
			Acute oral	LD_{50} 22 µg ac/bee	Bull & Wilkinson 1987
				LD_{50} 14 µg ac/bee	Bruhnke 2007
				LD_{50} >35 µg ac/bee	Stevenson 1978
SL 200 g/L	*Apis mellifera*	Adult	Acute contact	LD_{50} 16 µg ac/bee	Bull & Wilkinson 1987
			Acute oral	LD_{50} 13 µg ac/bee	Bull & Wilkinson 1987

Table 63: Paraquat – Laboratory studies on other arthropod species

Substance	Group	Species	Test substrate	Toxicity value	Reference
SL 200 g/L	Predatory arthropods	*Typhlodromus pyri*	Glass plate	100% mortality at 1100 g ac/ha	Gill & Austin 1996
SL 100 g/L	Predatory arthropods	*Typhlodromus pyri*	Glass plate	LR_{50} 1.9 g ac/ha	Austin & Elcock 1999a
			Bean leaf disc	LR_{50} 8.2 g ac/ha ER_{50} >4.0 g ac/ha	Austin 1999a
		Pterostichus melanarius *Pardosa spp.*	Loamy sand Loamy sand	LR_{50} >1000 g ac/ha LR_{50} >1000 g ac/ha	Jackson et al, 1991
	Parasitic arthropods	*Aleochara bilineata*	Quartz sand	ER_{50} >600 g ac/ha	Petto 1993

Table 64: Paraquat – Field studies on other arthropod species

Substance	Crop	Exposure	Effect	Reference
SL 100 g/L	Winter wheat	1× 300 g ac/ha post-harvest	Short-term effects on arthropod populations were observed, this may in part be attributable to loss of vegetation; recovery was observed by following spring/summer	Kendall et al, 1989

Table 65: Paraquat – Laboratory studies on soil organisms

Substance	Group	Exposure	Species	Toxicity value	Reference
SL 200 g/L	Macro-organisms	Acute	*Eisenia fetida*	LC_{50} >1000 mg ac/kg ds	Edwards & Coulson 1993, Lane & Vaughan 1997

Table 66: Paraquat – Field studies on soil organisms

Substance	Exposure	Effect	Reference
Paraquat	0, 90, 198 and 720 kg ac/ha (0, 50, 110 and 400% SAC) incorporated to 150 mm	No adverse effects on soil micro-organisms were observed	Drew & Davies 1980
	0, 90, 198 and 720 kg ac/ha (0, 50, 110 and 400% SAC) incorporated to 150 mm	Reduced abundance of Collembola and Gamisina observed in 720 kg ac/ha treatment after one year – though this may have been due to changes in vegetation cover	Cole & Wilkinson 1980
	0, 15, 33 and 120 kg ac/ha (0, 50, 110 and 400% SAC) incorporated to 25 mm	Reduced earthworm abundance and/or biomass was observed in 120, 198 and 720 kg ac/ha treatments after one year and abundance only at 720 kg ac/ha after 6 years. No effect on biomass was observed after 6 years.	Edwards 1980
	1× 2.24, 114, 561 and 1700 kg ac/ha Multiple applications to achieve total rates of 260 and 565 kg ac/ha	Effects on earthworms were investigated. No adverse effects on *lumbricidae* or *enchytraeid* abundance, attributable to paraquat, were reported. SAC not reported	Wilkinson & Edwards 1993

Table 67: Paraquat – Effects on non-target terrestrial plants

Substance	Exposure	Species	ER_{25}	ER_{50}	Reference
SL 240 g/L	Pre-emergent	*Brassica napus*	>1166 g ac/ha	>1166 g ac/ha	Martin 2014(a)
		Zea mays	>1166 g ac/ha	>1166 g ac/ha	
		Allium cepa	>1267 g ac/ha	>1267 g ac/ha	
		Avena sativa	712 g ac/ha	>1267 g ac/ha	
		Cucumus sativus	>1267 g ac/ha	>1267 g ac/ha	
		Glycine max	>1267 g ac/ha	>1267 g ac/ha	
		Lolium perenne	>639 g ac/ha	>1267 g ac/ha	
		Lycopersicon esculentum	>1267 g ac/ha	>1267 g ac/ha	
		Phaseolus vulgaris	>1267 g ac/ha	>1267 g ac/ha	
		Raphanus sativus	>1267 g ac/ha	>1267 g ac/ha	
	Post-emergent	*Lolium perenne*	23 g ac/ha	35 g ac/ha	Martin 2014(b)
		Zea mays	30 g ac/ha	80 g ac/ha	
		Avena sativa	47 g ac/ha	108 g ac/ha	
		Allium cepa	23 g ac/ha	136 g ac/ha	
		Lycopersicon esculentum	47 g ac/ha	188 g ac/ha	
		Cucumis sativus	99 g ac/ha	267 g ac/ha	
		Glycine max	24 g ac/ha	297 g ac/ha	
		Brassica napus	36 g ac/ha	>314 g ac/ha	
		Phaseolus vulgaris	>314 g ac/ha	>314 g ac/ha	
		Raphanus sativus	182 g ac/ha	>314 g ac/ha	
SL 300 g/L	Post-emergent	*Xanthium strumarium*	14 g ac/ha	25 g ac/ha	Canning & White 1992
		Beta vulgaris	20 g ac/ha	68 g ac/ha	
		Brassica napus	46 g ac/ha	83 g ac/ha	
		Abutilon theophrasti	50 g ac/ha	135 g ac/ha	
		Ipomoea hederacea	111 g ac/ha	201 g ac/ha	
		Zea mays	198 g ac/ha	536 g ac/ha	
		Glycine max	101 g ac/ha	>763 g ac/ha	

Table 68: Diquat/paraquat combination products: short-term effects on terrestrial vertebrates

Group	Species	0.46 diquat[43]	0.54 paraquat[44]	1.00 combination[45]
Mammals	*Rattus norvegicus*	LD_{50} 208 mg ac/kg bw Rittenhouse 1979 McCall & Robinson 1990	LD_{50} 111 mg ac/kg bw Duerden 1994 Kibrough & Gaines 1970 Murray & Gibson 1972	Measured: LD_{50} 119 mg acs/kg bw Pooles 2005 Predicted: LD_{50} 141 mg acs/kg bw MDR 0.84
	Mus musculus	LD_{50} 125 mg ac/kg bw Clark & Hurst 1970	LD_{50} 151 mg ac/kg bw Fletcher 1967 Heylings & Farnworth 1992	Predicted: LD_{50} 138 mg acs/kg bw Relative toxicity: 51% + 49%
	Cavia porcellus	LD_{50} ~100 mg ac/kg bw Clark & Hurst 1970	LD_{50} 22 mg ac/kg bw Murray & Gibson 1972	Predicted: LD_{50} 34 mg acs/kg bw

[43] All formulations contain 115 g/L diquat, which comprises 46% of the total active constituent

[44] All formulations contain 135 g/L paraquat, which comprises 54% of the total active constituent

[45] Refer to **APVMA Risk Assessment Manual – Environment** for calculation method to predict combination toxicity

Group	Species	0.46 diquat[43]	0.54 paraquat[44]	1.00 combination[45]
				Relative toxicity: 16% + 84%
Mammals	*Oryctolagus cuniculus*	LD_{50} 101 mg ac/kg bw Clark & Hurst 1970	LD_{50} 45 mg ac/kg bw Farnworth et al, 1993	Predicted: LD_{50} 60 mg acs/kg bw Relative toxicity: 28% + 72%
				Geomean LD_{50} 76 mg acs/kg bw (4 mammal species)
Birds	*Anas platyrhynchos*	LD_{50} 71 mg ac/kg bw Fink et al, 1982b	LD_{50} 54 mg ac/kg bw Johnson 1998	Predicted: LD_{50} 61 mg acs/kg bw Relative toxicity: 39% + 61%
	Taeniopygia guttata	LD_{50} 31 mg ac/kg bw Hubbard 2013	LD_{50} 27 mg ac/kg bw Hubbard et al, 2014	Predicted: LD_{50} 29 mg acs/kg bw Relative toxicity: 43% + 47%
	Perdix perdix / Colinus virginianus	LD_{50} 158 mg ac/kg bw (*Perdix perdix*) Roberts & Fairley 1980	LD_{50} 124 mg ac/kg bw (*Colinus virginianus*) Fink et al, 1979	Predicted: LD_{50} 138 mg acs/kg bw Relative toxicity: 40% + 60%
				Geomean LD_{50} 62 mg acs/kg bw (3 bird species)

Table 69: Diquat/paraquat combination products: short-term effects on aquatic species46

Group	Species	0.46 diquat[47]	0.54 paraquat[48]	1.00 combination[49]
Fish	*Cyprinodon variegatus*	meas. 4d LC_{50} 49 mg ac/L adj. LC_{50} 59 mg ac/L Nicholson 1987	meas. 4d LC_{50} >41 mg ac/L adj. LC_{50} >50 mg ac/L Claude et al, 2014(a)	Predicted: LC_{50} >54 mg acs/L Relative toxicity: ≤42% + ≥58%
	Sander vitreus	meas. 4d LC_{50} 0.75 mg ac/L adj. LC_{50} 0.91 mg ac/L Paul et al, 1994	No data[50]	Predicted: LC_{50} 1.7 mg acs/L Relative toxicity: 84% + 16%

[46] All 'measured' endpoints have been adjusted to account for rapid dissipation from the water column under natural conditions (adjusted EC_{50} = measured EC_{50} / (1 – EXP (exposure days * (-ln(2)/DT_{50} 7.0 days))) (exposure days * ln(2)/DT_{50} 7.0 days). The more conservative water DT_{50} of 7 days for paraquat has been utilised to adjust the endpoints for both chemicals to avoid artificially skewing the relative toxicity contributions toward paraquat.

[47] All formulations contain 115 g/L diquat, which comprises 46% of the total active constituent

[48] All formulations contain 135 g/L paraquat, which comprises 54% of the total active constituent

[49] Refer to **APVMA Risk Assessment Manual – Environment** for calculation method to predict combination toxicity; predicted values are based on adjusted toxicity values to account for rapid dissipation of both active constituents from the water column

[50] Where toxicity data are not available, the endpoint for the most sensitive species was selected to predict combination toxicity

Group	Species	0.46 diquat[47]	0.54 paraquat[48]	1.00 combination[49]
	Pimephales promelas	No data	meas. 4d LC_{50} 4.7 mg ac/L adj. LC_{50} 5.7 mg ac/L Claude et al, 2014(b)	Predicted: LC_{50} 1.7 mg acs/L Relative toxicity: 84% + 16%
Invertebrates	*Americamysis bahia*	meas. 4d LC_{50} 0.42 mg ac/L adj. LC_{50} 0.51 mg ac/L Hoberg 1987	meas. 4d LC_{50} 0.23 mg ac/L adj. LC_{50} 0.28 mg ac/L Claude et al, 2014(e)	Predicted: LC_{50} 0.35 mg acs/L Relative toxicity: 32% + 68%
	Daphnia magna	meas. 2d EC_{50} 2.5 mg ac/L adj. EC_{50} 2.8 mg ac/L Volz 2004	meas. 2d EC_{50} 4.3 mg ac/L adj. EC_{50} 4.8 mg ac/L Allison & Hamer 1990 Noack 2007	Predicted: EC_{50} 3.6 mg acs/L Relative toxicity: 59% + 41%
	Crassostrea virginica	meas. 4d EC_{50} 141 mg ac/L adj. EC_{50} 171 mg ac/L Dionne 1987	meas. 4d EC_{50} 23 mg ac/L adj. EC_{50} 28 mg ac/L Claude et al, 2014f	Predicted: EC_{50} 46 mg acs/L Relative toxicity: 12% + 88%
	Hyalella azteca	meas. 4d LC_{50} 0.084 mg ac/L adj. LC_{50} 0.10 mg ac/L Bender 2006a	No data	Predicted: LC_{50} 0.15 mg acs/L Relative toxicity: 70% + 30%
Algae	*Navicula pelliculosa*	meas. 3d E_rC_{50} 0.0012 mg ac/L adj. E_rC_{50} 0.0014 mg ac/L Smyth et al, 1998(a)	meas. 3d E_rC_{50} 0.00034 mg ac/L adj. E_rC_{50} 0.00041 mg ac/L Smyth et al, 1992(a)	Predicted E_rC_{50}: 0.00061 mg acs/L Relative toxicity: 20% + 80%
	Raphidocelis subcapitata	meas. 4d EC_{50} 0.055 mg ac/L adj. EC_{50} 0.067 mg ac/L Nagai 2019	meas. 4d EC_{50} 0.22 mg ac/L adj. EC_{50} 0.26 mg ac/L Smyth et al, 1990(a), 1990(b), 1992(b) Scheerbaum 2007(b)	Predicted: EC_{50} 0.011 mg acs/L Relative toxicity: 77% + 23%
	Anabaena flos-aquae	meas. 3d E_rC_{50} 0.025 mg ac/L adj. E_rC_{50} 0.029 mg ac/L Smyth et al, 1998b	meas. 3d E_rC_{50} 0.0078 mg ac/L adj. E_rC_{50} 0.0099 mg ac/L Smyth et al, 1992)c)	Predicted E_rC_{50}: 0.014 mg acs/L Relative toxicity: 23% + 77%
	Skeletonema costatum	meas. 3d E_rC_{50} 12 mg ac/L adj. E_rC_{50} 14 mg ac/L Smyth et al, 1998c	meas. 3d E_rC_{50} 5.9 mg ac/L adj. E_rC_{50} 7.1 mg ac/L Smyth et al, 1998(d)	Predicted: E_rC_{50} 9.2 mg acs/L Relative toxicity: 30% + 70%
Aquatic plants	*Lemna gibba*	meas. 14d EC_{50} 0.0032 mg ac/L adj. EC_{50} 0.0059 mg ac/L Magor & Shillabeer 2001	meas. 7/14d* E_rC_{50} 0.038 mg ac/L adj. E_rC_{50} 0.061 mg ac/L Mohammad et al, 2010 Smyth et al, 1992e	Predicted: EC_{50} 0.012 mg acs/L Relative toxicity: 89% + 11%
	Lemna minor	No data	meas. 7d E_rC_{50} 0.015 mg ac/L adj. E_rC_{50} 0.021 mg ac/L Tagun & Boxall 2018	Predicted: EC_{50} 0.0096 mg acs/L Relative toxicity: 75% + 25%

Group	Species	0.46 diquat[47]	0.54 paraquat[48]	1.00 combination[49]
Primary producers				Geomean EC_{50} 0.010 mg acs/L (5 species, excl. *S.costatum*)

*7d E_rC_{50} 0.031 and 14d E_rC_{50} 0.047 mg ac/L

Table 70: Diquat/paraquat combination products: short-term effects on bees

Group	Species	0.46 diquat[51]	0.54 paraquat[52]	1.00 combination[53]
Bees (contact)	*Apis mellifera*	LD_{50} 105 µg ac/bee Gough et al, 1987	LD_{50} 16 µg ac/bee Bull & Wilkinson 1987	Predicted: LD_{50} 26 µg acs/bee Relative toxicity: 11% + 89%
Bees (oral)	*Apis mellifera*	LD_{50} 22 µg ac/bee Gough et al, 1987	LD_{50} 13 µg ac/bee Bull & Wilkinson 1987	Predicted: LD_{50} 16 µg acs/bee Relative toxicity: 33% + 67%

Table 71: Diquat/paraquat combination products: effects on other terrestrial arthropods

Group	Species	0.46 diquat[54]	0.54 paraquat[55]	1.00 combination[56]
Predatory arthropods	*Typhlodromus pyri*	Tier 1 LR_{50} 2.9 g ac/ha Austin & Elcock 1999b	Tier 1 LR_{50} 1.9 g ac/ha Austin & Elcock 1999a	Predicted tier 1: LR_{50} 2.3 g acs/ha Relative toxicity: 36% + 64%
		Tier 2 LR_{50} 4.1 g ac/ha Austin & Elcock 1999c	Tier 2 LR_{50} 8.2 g ac/ha Austin 1999a	Predicted tier 2: LR_{50} 5.6 g acs/ha Relative toxicity: 63% + 37%
	Pterostichus melanarius	ER_{50} >1600 g ac/ha Gough et al, 1991	ER_{50} >1000 g ac/ha Jackson et al, 1991	Not expected to be toxic
	Pardosa spp.	ER_{50} >1600 g ac/ha Gough et al, 1991	ER_{50} >1000 g ac/ha Jackson et al, 1991	Not expected to be toxic
Parasitic arthropods	*Aphidius rhopalosiphi*	Tier 1 LR_{50} 3.2 g ac/ha Austin 1999b	No data	Insufficient data
		Tier 2 LR_{50} 758 g ac/ha Austin 1999c	No data	Insufficient data
	Aleochara bilineata	ER_{50} >1000 g ac/ha Beech 1997	ER_{50} >600 g ac/ha Petto 1993	Not expected to be toxic

[51] All formulations contain 115 g/L diquat, which comprises 46% of the total active constituent
[52] All formulations contain 135 g/L paraquat, which comprises 54% of the total active constituent
[53] Refer to **APVMA Risk Assessment Manual – Environment** for calculation method to predict combination toxicity
[54] All formulations contain 115 g/L diquat, which comprises 46% of the total active constituent
[55] All formulations contain 135 g/L paraquat, which comprises 54% of the total active constituent
[56] Refer to **APVMA Risk Assessment Manual – Environment** for calculation method to predict combination toxicity

Table 72: Diquat/paraquat combination products: short-term effects on soil organisms

Group	Species/process	0.46 diquat[57]	0.54 paraquat[58]	1.00 combination[59]
Macro-organisms	*Eisenia fetida*	LC_{50} 94 mg ac/kg ds Bender 2006b	LC_{50} >1000 mg ac/kg ds Bender 2006b	Any toxicity would be attributed to diquat
Micro-organisms	Nitrification	NOEC 500 mg ac/kg ds Schulz 2007b	NOEC 120 mg ac/kg ds Drew & Davies 1980	Not expected to be toxic

Table 73: Diquat/paraquat combination products: effects on non-target terrestrial plants (post-emergent exposure)

Group	Species	0.46 diquat[60]	0.54 paraquat[61]	1.00 combination[62]
Monocotyledons	*Zea mays*	ER_{50} 205 g ac/ha Bellet 1990b Martin 2013 Porch & Krueger 1999	ER_{50} 207 g ac/ha Canning & White 1992 Martin 2014	Predicted: ER_{50} 206 g acs/ha Relative toxicity: 46% + 54%
	Allium cepa	ER_{50} 252 g ac/ha Bellet 1990b Martin 2013	ER_{50} 136 g ac/ha Martin 2014	Predicted: ER_{50} 173 g acs/ha Relative toxicity: 31% + 69%
	Lolium perenne	ER_{50} 445 g ac/ha Martin 2013	ER_{50} 35 g ac/ha Martin 2014	Predicted: ER_{50} 61 g acs/ha Relative toxicity: 6% + 91%
	Avena sativa	ER_{50} >500 g ac/ha Martin 2013	ER_{50} 108 g ac/ha Martin 2014	Predicted: ER_{50} >169 g acs/ha Relative toxicity: ≤16% + ≥84%
Dicotyledons	*Brassica oleracea / Xanthium strumarium*	ER_{50} 15 g ac/ha (*Brassica oleracea*) Martin 2013	ER_{50} 25 g ac/ha (*Xanthium strumarium*) Canning & White 1992	Predicted: ER_{50} 19 g acs/ha Relative toxicity: 59% + 41%
	Beta vulgaris	ER_{50} 38 g ac/ha Martin 2013	ER_{50} 68 g ac/ha Canning & White 1992	Predicted: ER_{50} 50 g acs/ha Relative toxicity: 60% + 40%
	Brassica napus	ER_{50} 57 g ac/ha Martin 2013	ER_{50} 161 g ac/ha Canning & White 1992 Martin 2014	Predicted: ER_{50} 88 g acs/ha Relative toxicity: 71% + 29%

[57] All formulations contain 115 g/L diquat, which comprises 46% of the total active constituent
[58] All formulations contain 135 g/L paraquat, which comprises 54% of the total active constituent
[59] Refer to **APVMA Risk Assessment Manual – Environment** for calculation method to predict combination toxicity
[60] All formulations contain 115 g/L diquat, which comprises 46% of the total active constituent
[61] All formulations contain 135 g/L paraquat, which comprises 54% of the total active constituent
[62] Refer to **APVMA Risk Assessment Manual – Environment** for calculation method to predict combination toxicity

Group	Species	0.46 diquat[60]	0.54 paraquat[61]	1.00 combination[62]
	Glycine max	ER_{50} 138 g ac/ha Bellet 1990b Martin 2013	ER_{50} 476 g ac/ha Canning & White 1992 Martin 2014	Predicted: ER_{50} 224 g acs/ha Relative toxicity: 75% + 25%
	Phaseolus vulgaris	ER_{50} 884 g ac/ha Bellet 1990b	ER_{50} >314 g ac/ha Martin 2014	Predicted: ER_{50} >446 g acs/ha Relative toxicity: ≥23% + ≤77%

Appendix C – Terrestrial vertebrate assessments

Risk assessment (according to EFSA 2009)

Risks to terrestrial vertebrates following dietary exposure to contaminated food items are assessed using a tiered approach. The acute assessment assumes 100% of food items are obtained from the treatment area on the last day of application, while the chronic assessment assumes 50% of food items are obtained from the treatment area for the first 21 days after the last application (PT 0.5).

The use patterns were divided up into groups which consist of crops that have similar growing patterns (Table 74). It is assumed that the exposure of a 'generic focal species' within each group will be the same as they relate to feeding habits and other ecological needs. A 'generic focal species' is not a real species; however, it is considered representative of all those species potentially at risk. The APVMA utilises the EFSA (2009) generic focal species which are considered protective of species that occur in Australia. Interception of the spray by the crop is accounted for by calculating the residue level on the several food types, depending on the growth stage of the crop. This consideration is reflected in the EFSA (2009) shortcut values.

The maximum acceptable application rate following both acute and chronic exposure for each application timing have been calculated in this document to compare against the full rate ranges registered for each situation (Table 75 for wild mammals; Table 76 for birds). Only application timings considered relevant for the use situation have been considered. Note that these assessments do not include any refinements. Refinements to the risk assessment are considered in the following section.

Table 74: Seasonal exposure estimates for paraquat in animal food items

Category	EFSA 2009 crop group	Situation	Application rate and frequency	FFT	Seasonal exposure rate (g/ha)[63]
					Maximum
General weed control	Bare soil	Fallow (optical spot spraying)	From 1× 2250 g ac/ha	0.3	675
		Fallow	From 1× 1505 g ac/ha	1.0	1505
		Market gardens, row crops, vegetables	From 1× 600 g ac/ha	1.0	600
		Market gardens, row crops, vegetables (shielded inter-row spraying)	From 1× 600 g ac/ha	1.0[64]	600
		Hops, rice (pre/post sowing), potatoes (pre/early emergence)	From 1× 400 g ac/ha	1.0	400

[63] The maximum on-label use rates for each set of use situations are indicated, there may be lower rates which have not been reproduced for the sake of brevity

[64] The use situations market gardens, row crops and vegetables are imprecisely defined such that it is not clear whether an FFT refinement would be appropriate, and if it were what a suitably conservative value would be. Additional information would be required to justify an appropriate FFT factor.

Category	EFSA 2009 crop group	Situation	Application rate and frequency	FFT	Seasonal exposure rate (g/ha)[63]
					Maximum
	Grassland	Industrial vegetation management	From 1× 1140 g ac/ha	1.0	1140
		Pasture (includes hay freezing, spray topping to reduce seed set, prevention of ryegrass toxicity, perennial grass seed crops and kikuyu/paspalum pasture)	From 1× 600 g ac/ha	1.0	600
	Legume forage	Lucerne (ungrazed before spraying)	From 1× 600 g ac/ha	1.0	600
		Peanuts (BBCH 10-19)	From 1× 250 g ac/ha	1.0	250
	Maize[65]	Sugarcane (over the top spray)	From 1× 400 g ac/ha	1.0	400
		Sugarcane (inter-row spray)	From 1× 400 g ac/ha	1.0	400
	Orchards	Orchards, bananas	From 1× 1120 g ac/ha	1.0	1120
		Spot spray in orchards, bananas	From 1× 1120 g ac/ha	0.4	448
	Potato	Potatoes (pre-harvest)	From 1× 700 g ac/ha	1.0	700
	Pulses	Spray topping in pulses	1× 200 g ac/ha	1.0	200
	Vineyards	Vineyards	From 1× 1120 g ac/ha	1.0	1120
		Spot spray in vineyards	From 1× 1120 g ac/ha	0.4	448
Combination products containing diquat	Bare soil	Fallow (minimal disturbance)	From 2× 432 g ac/ha 7d interval	1.0	698
		Fallow (minimal disturbance)	From 1× 432 g ac/ha	1.0	432
		Fallow (full disturbance)	From 1× 324 g ac/ha	1.0	324
		Market gardens, nurseries, potatoes (pre/early emergence), rice (pre-emergence), vegetables	From 1× 432 g ac/ha	1.0	432
		Spot spray in market gardens, nurseries, potatoes (pre/early emergence)	From 1× 432 g ac/ha	0.4	173
	Cotton	Cotton desiccant	From 1× 216 g ac/ha	1.0	216
	Grassland	Pasture, public service areas, rights of way	From 1× 432 g ac/ha	1.0	432
		Spot spray in public service areas, rights of way	From 1× 432 g ac/ha	0.4	173
	Legume forage	Lucerne (grazed before	From 1× 324 g ac/ha	1.0	324

[65] For sugarcane situations the maize crop group has been used, as a specific crop group for sugarcane is not defined in EFSA 2009. For both over the top and inter-row sprays the generic focal species present at BBCH 10-19 have been modelled. Whilst the inter-row spray may occur from the 3-4 leaf stage up to the formation of the true stem the application method means the interception assumed at later growth stages is not appropriate. So, for the purposes of a Tier 1 risk assessment the earlier growth stage without interception has been used to establish feeding guilds potentially at risk.

Category	EFSA 2009 crop group	Situation	Application rate and frequency	FFT	Seasonal exposure rate (g/ha)[63]
					Maximum
		spraying)[66]			
	Maize	Sugarcane (over the top spray)	From 1× 270 g ac/ha	1.0	270
		Sugarcane (inter-row spray)	From 1× 270 g ac/ha	1.0	270
	Potato	Potatoes (pre-harvest)	1× 432 g ac/ha	1.0	432
		Spot spray in potatoes (pre-harvest)	1× 432 g ac/ha	0.4	173
	Orchards	Forests, orchards, plantations, bananas, dubosia, tea tree	From 1× 432 g ac/ha	1.0	432
		Spot application in orchards, plantations, bananas, dubosia	From 1× 432 g ac/ha	0.4	173
		Spot application in avocado, custard apples, lychees, mangos	From 2× 324 g ac/ha 14d interval	0.4	179
	Vineyards	Vineyards	From 1× 432 g ac/ha	1.0	432
		Spot application in vineyards	From 1× 432 g ac/ha	0.4	173
Combination products containing amitrole	Bare soil	Fallow (optical spot spraying)	From 1× 1680 g ac/ha	0.3	504
		Fallow	From 1× 600 g ac/ha	1.0	600
	Grassland	Industrial vegetation management	From 1× 850 g ac/ha	1.0	850
		Spot spray in industrial vegetation management	From 1× 500 g ac/ha	0.4	200
		Pasture	From 1× 300 g ac/ha	1.0	300
	Orchards	Orchards	From 1× 600 g ac/ha	1.0	600
		Spot spray in orchards	1× 500 g ac/ha	0.4	200
	Potato	Potatoes (pre-harvest)	1× 525 g ac/ha	1.0	525
	Vineyards	Vineyards	From 1× 600 g ac/ha	1.0	600
		Spot spray in vineyards	1× 500 g ac/ha	0.4	200

Risk assessment scenarios as described in APVMA 2024 but with modifications to account for comments and omissions/errors in original report

FFT = fraction of field treated = 0.3 for optical spot sprayer uses (as per on-label instructions), and 0.4 for spot sprayer uses (default value)

Seasonal exposure rates are based on the indicated application rate, frequency, FFT and default DT_{50} (10 d)

Seasonal exposure rate, single application = application rate × FFT

Seasonal exposure rate, multiple applications = application rate × (1 – EXP(-1 × number of applications × ln(2) ⁄ DT_{50} × application interval)) ⁄ (1 – EXP(-1 × ln(2) ⁄ DT_{50} × application interval)) × FFT

[66] Where grazing occurs immediately before application for lucerne, the risk assessment only considers up to BBCH 19 to account for the limited crop cover

Table 75: Assessment of risks to wild mammals (acute RAL 6.1 mg/kg bw; chronic 3.8 mg ac/kg bw/d)

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
General weed control in fallow (including minimal/full disturbance, and optical spot spraying), hops, market gardens, nurseries, row crops, potatoes (pre/early emergence), rice (pre/post sowing), vegetables	Bare soil	Small omnivore	BBCH <10	14.3	5.7	**427**	2531
Pre-harvest desiccation in cotton	Cotton	Small herbivore	BBCH ≥50	34.1	18.1	**179**	797
		Small omnivore	BBCH ≥50	4.3	1.9	1419	7594
		Small insectivore	BBCH ≥50	5.4	1.9	1130	7594
General weed control in industrial vegetation management, pasture, public service areas, rights of way	Grassland	Small herbivore	All season	136.4	72.3	**45**	**200**
		Large herbivore	All season	32.6	17.3	**187**	**834**
		Small omnivore	New sown or late season	14.4	6.6	**424**	2186
		Small insectivore	Late season	5.4	1.9	**1130**	7594
General weed control in lucerne (ungrazed before application)	Legume forage	Small herbivore	BBCH ≥50	40.9	21.7	**149**	665
		Small omnivore	BBCH ≥50	5.2	2.3	1173	6273
		Small insectivore	BBCH ≥20	5.4	1.9	1130	7594
General weed control in peanuts (BBCH 10-19), lucerne (grazed before application)	Legume forage/pulses	Small omnivore	BBCH 10-49	17.2	7.8	355	1850
		Small insectivore	BBCH 10-19	7.6	4.2	803	3435
General weed control in sugarcane (over the top spray and inter-row spray)	Maize	Small herbivore	BBCH 10-29	136.4	72.3	**45**	**200**
		Small omnivore	BBCH 10-29	17.2	7.8	**355**	1850
		Small insectivore	BBCH 10-19	7.6	4.2	803	3435
General weed control in bananas, dubosia, forests, orchards, plantations, tea tree, and tropical fruits	Orchards	Small herbivore	Ground directed	136.4	72.3	**45**	**200**
		Large herbivore	Ground directed	35.1	14.3	**174**	**1009**
		Small omnivore	Ground directed	17.2	7.8	**355**	1850
		Small insectivore	Ground directed	5.4	1.9	1130	7594
General weed control in potatoes	Potatoes	Small herbivore	BBCH ≥40	40.9	21.7	**149**	**665**
		Large herbivore	BBCH ≥40	10.5	4.3	**581**	3355

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
(pre-harvest)		Small omnivore	BBCH ≥40	5.2	2.3	1173	6273
		Small insectivore	BBCH ≥20	5.4	1.9	1130	7594
Spray topping in pulses	Pulses	Small herbivore	BBCH ≥50	40.9	21.7	**149**	665
		Large herbivore	BBCH ≥50	10.5	4.3	581	3355
		Small omnivore	BBCH ≥50	5.2	2.3	1173	6273
			BBCH 81-99	14.4	6.6	424	2186
		Small insectivore	BBCH ≥20	5.4	1.9	1130	7594
General weed control in vineyards	Vineyards	Small herbivore	Ground directed	136.4	72.3	**45**	**200**
		Large herbivore	Ground directed	27.2	11.1	**224**	1300
		Small omnivore	Ground directed	17.2	7.8	**355**	1850

Crop groups and situations as indicated in Table 74
Generic focal species and shortcut values for indicated crop groups from EFSA (2009)
RAL = regulatory acceptable level
Acute = geomean LD_{50} 61 mg/kg bw (Duerden 1994, Farnworth et al. 1993, Fletcher 1967, Heylings & Farnworth 1992, Kimbrough & Gaines 1970, Murray & Gibson 1972) and assessment factor of 10
Chronic = NOAEL 3.8 mg/kg bw/d (Lindsay 1982a, 1982b) and assessment factor of 1
Maximum acceptable rate (g ac/ha)
= RAL × 1000 ⁄ (shortcut value × PT (acute 1.0, chronic 0.5) × TWA factor (acute 1.0, chronic 0.53))
Acceptable rates in bold indicate where the acceptable use rate is lower than the maximum seasonal rate for the use situations as quoted in Table 74. Therefore, further refinement would be required to demonstrate an acceptable risk for one or more on-label use rates.

Table 76: Assessment of risks to birds (acute RAL 5.7 mg/kg bw; chronic RAL 2.7 mg ac/kg bw/d)

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
General weed control in fallow (including minimal/full disturbance, and optical spot spraying), hops, market gardens, nurseries, row crops, potatoes (pre/early emergence), rice (pre/post sowing), vegetables	Bare soil	Small granivore	BBCH <10	24.7	11.4	**231**	899
		Small omnivore	BBCH <10	17.4	8.2	**328**	1250
		Small insectivore	BBCH <10	10.9	5.9	**523**	1738
Pre-harvest desiccation in cotton	Cotton	Small omnivore	BBCH ≥50	4.4	2.8	1295	3661
		Small insectivore	BBCH ≥20	3.0	1.1	1900	9320

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
General weed control in industrial vegetation management, pasture, public service areas, rights of way	Grassland	Small granivore	Late season	24.7	11.4	**231**	**899**
		Large herbivore	Growing shoots	30.5	16.2	**187**	**633**
		Small insectivore	Growing shoots	26.8	11.3	**213**	**907**
General weed control in lucerne (ungrazed before application)	Legume forage	Small granivore	BBCH ≥50	7.4	3.4	770	3015
		Small omnivore	BBCH ≥50	7.2	3.3	792	3107
		Small insectivore	BBCH ≥20	25.2	9.7	**226**	1057
General weed control in peanuts (BBCH 10-19), lucerne (grazed before application)	Legume forage	Small granivore	BBCH 10-49	24.7	11.4	**231**	899
		Small omnivore	BBCH 10-49	24.0	10.9	**238**	941
		Small insectivore	BBCH 10-19	26.8	11.3	**213**	907
General weed control in sugarcane (over the top spray and inter-row spray)	Maize	Medium herbivore/ granivore	BBCH 10-29	55.6	22.7	**103**	452
		Medium granivore	BBCH 10-29	6.6	3.0	864	3417
		Small omnivore	BBCH 10-29	24.0	10.9	**238**	941
		Small insectivore	BBCH 10-19	26.8	11.3	**213**	907
		Small insectivore/worm feeding	BBCH 10-19	10.5	5.7	543	1799
General weed control in bananas, dubosia, forests, orchards, plantations, tea tree, vineyards	Orchards	Small granivore	Ground directed	27.4	12.6	**208**	**814**
		Small insectivore/worm feeding	Ground directed	7.4	2.7	**770**	3797
General weed control in potatoes (pre-harvest)	Potatoes	Small omnivore	BBCH ≥40	7.2	3.3	792	3107
		Small insectivore	BBCH ≥20	25.2	9.7	**226**	1057
Spray topping in pulses	Pulses	Small granivore	BBCH ≥50	7.4	3.4	770	3015
		Small omnivore	BBCH ≥50	7.2	3.3	792	3107
		Small insectivore	BBCH ≥20	25.2	9.7	226	1057

Crop groups and situations as indicated in Table 74
Generic focal species and shortcut values for indicated crop groups from EFSA (2009)
RAL = regulatory acceptable level
Acute = geomean LD_{50} 57 mg/kg bw (Fink et al. 1979, Hubbard et al. 2014 and Johnson 1998) and assessment factor of 10
Chronic = NOEL 2.7 mg/kg bw/d (Fink et al. 1982) and assessment factor of 1
Maximum acceptable rate (g ac/ha)
= RAL × 1000 ⁄ (shortcut value × PT (acute 1.0, chronic 0.5) × TWA factor (acute 1.0, chronic 0.53))
Acceptable rates in bold indicate where the acceptable use rate is lower than the maximum seasonal rate for the use situations as quoted in Table 74. Therefore, further refinement would be required to demonstrate an acceptable risk for one or more on-label use rates.

Refined risk assessments

Quantitative refinements of the risk assessment have been included to account for the following factors:

Small herbivorous mammals – The body weight for the small herbivorous mammal has been adjusted to 50 g. All other parameters are the default values used in EFSA (2009) and the shortcut values have been adjusted accordingly.

Large herbivorous mammals – The daily energy expenditure (DEE) has been adjusted to reflect an allometric equation for non-eutherian mammals. The assumed body weight (1500 g) has also been adjusted to reflect Australian species. All other parameters are the default values used in EFSA (2009) and the shortcut values have been adjusted accordingly.

Crop interception – Crop interception/deposition values have been adjusted to reflect those from EFSA (2020), where appropriate for the combination of crop, growth stage and food item.

Residue decline – For insect food items a DT_{50} of 4.6 d has been established, this will be used to refine the MAF and TWA for relevant food items where appropriate. For all other food items the default DT_{50} (10 d) will be applied.

Risk assessments have been conducted, incorporating the quantitative refinements identified above where relevant, for the combinations of crops groups, exposure routes (acute/chronic) and generic focal species with unresolved risks (Table 77 for wild mammals; Table 78 for birds). Only application timings considered relevant for the use situation have been considered. A comprehensive set of on-label use rates have been considered, but not every iteration of minor variations (e.g. within ± 5 g/ha) for the same use pattern, between different product labels, has been included.

Table 77: Refined assessment of risks to wild mammals (acute RAL 6.1 mg/kg bw; chronic 3.8 mg ac/kg bw/d)

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
General weed control in fallow (including minimal/full disturbance, and optical spot spraying), hops, market gardens, nurseries, row crops, potatoes (pre/early emergence), rice (pre/post sowing), vegetables												
Bare soil	Small omnivore	BBCH <10	Acute	14.3	1505	1.0	1.0	1.0	22	6.1	3.5	427
				14.3	675	1.0	1.0	1.0	9.7	6.1	1.6	427
				14.3	600	1.0	1.0	1.0	8.6	6.1	1.4	427
				14.3	595	1.0	1.0	1.0	8.5	6.1	1.4	427
				14.3	525	1.0	1.0	1.0	7.5	6.1	1.2	427
				14.3	510	1.0	1.0	1.0	7.3	6.1	1.2	427
				14.3	504	1.0	1.0	1.0	7.2	6.1	1.2	427
				14.3	500	1.0	1.0	1.0	7.2	6.1	1.2	427
				14.3	450	1.0	1.0	1.0	6.4	6.1	1.1	427
				14.3	432	1.48[d]	1.0	1.0	9.1	6.1	1.5	288
				14.3	432	1.0	1.0	1.0	6.2	6.1	1.0	427

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				14.3	400	1.0	1.0	1.0	5.7	6.1	0.94	427
				14.3	390	1.0	1.0	1.0	5.6	6.1	0.91	427
				14.3	375	1.0	1.0	1.0	5.4	6.1	0.88	427
				14.3	350	1.0	1.0	1.0	5.0	6.1	0.82	427
				14.3	324	1.48[d]	1.0	1.0	6.9	6.1	1.1	288
				14.3	324	1.0	1.0	1.0	4.6	6.1	0.76	427
				14.3	300	1.0	1.0	1.0	4.3	6.1	0.70	427
				14.3	243	1.0	1.0	1.0	3.5	6.1	0.57	427
				14.3	216	1.48[d]	1.0	1.0	4.6	6.1	0.75	288
				14.3	216	1.0	1.0	1.0	3.1	6.1	0.51	427
				14.3	200	1.0	1.0	1.0	2.9	6.1	0.47	427
				14.3	188	1.0	1.0	1.0	2.7	6.1	0.44	427
				14.3	185	1.0	1.0	1.0	2.6	6.1	0.43	427
				14.3	173	1.0	1.0	1.0	2.5	6.1	0.41	427
				14.3	162	1.48[d]	1.0	1.0	3.4	6.1	0.56	288
				14.3	162	1.0	1.0	1.0	2.3	6.1	0.38	427
				14.3	150	1.0	1.0	1.0	2.1	6.1	0.35	427
				14.3	113	1.0	1.0	1.0	1.6	6.1	0.26	427
				14.3	108	1.0	1.0	1.0	1.5	6.1	0.25	427
Pre-harvest desiccation in cotton												
Cotton	Small herbivore	BBCH ≥50	Acute	28.0[a,c]	216	1.0	1.0	1.0	6.0	6.1	0.99	218
General weed control in industrial vegetation management, pasture, public service areas, rights of way												
Grassland	Small herbivore	All season	Acute	112.0[a]	1140	1.0	1.0	1.0	128	6.1	21	54
				112.0[a]	1125	1.0	1.0	1.0	126	6.1	21	54
				112.0[a]	1000	1.0	1.0	1.0	112	6.1	18	54
				112.0[a]	850	1.0	1.0	1.0	95	6.1	16	54
				112.0[a]	840	1.0	1.0	1.0	94	6.1	15	54
				112.0[a]	750	1.0	1.0	1.0	84	6.1	14	54
				112.0[a]	600	1.0	1.0	1.0	67	6.1	11	54
				112.0[a]	595	1.0	1.0	1.0	67	6.1	11	54
				112.0[a]	500	1.0	1.0	1.0	56	6.1	9.2	54
				112.0[a]	432	1.0	1.0	1.0	48	6.1	7.9	54
				112.0[a]	400	1.0	1.0	1.0	45	6.1	7.3	54
				112.0[a]	324	1.0	1.0	1.0	36	6.1	5.9	54
				112.0[a]	300	1.0	1.0	1.0	34	6.1	5.5	54
				112.0[a]	216	1.0	1.0	1.0	24	6.1	4.0	54

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				112.0[a]	203	1.0	1.0	1.0	23	6.1	3.7	54
				112.0[a]	200	1.0	1.0	1.0	22	6.1	3.7	54
				112.0[a]	173	1.0	1.0	1.0	19	6.1	3.2	54
				112.0[a]	165	1.0	1.0	1.0	18	6.1	3.0	54
				112.0[a]	160	1.0	1.0	1.0	18	6.1	2.9	54
				112.0[a]	150	1.0	1.0	1.0	17	6.1	2.8	54
				112.0[a]	108	1.0	1.0	1.0	12	6.1	2.0	54
				112.0[a]	100	1.0	1.0	1.0	11	6.1	1.8	54
				112.0[a]	75	1.0	1.0	1.0	8.4	6.1	1.4	54
	Large herbivore	All season	Acute	26.6[b]	1140	1.0	1.0	1.0	30	6.1	5.0	229
				26.6[b]	1125	1.0	1.0	1.0	30	6.1	4.9	229
				26.6[b]	1000	1.0	1.0	1.0	27	6.1	4.4	229
				26.6[b]	850	1.0	1.0	1.0	23	6.1	3.7	229
				26.6[b]	840	1.0	1.0	1.0	22	6.1	3.7	229
				26.6[b]	750	1.0	1.0	1.0	20	6.1	3.3	229
				26.6[b]	600	1.0	1.0	1.0	16	6.1	2.6	229
				26.6[b]	595	1.0	1.0	1.0	16	6.1	2.6	229
				26.6[b]	500	1.0	1.0	1.0	13	6.1	2.2	229
				26.6[b]	432	1.0	1.0	1.0	11	6.1	1.9	229
				26.6[b]	400	1.0	1.0	1.0	11	6.1	1.7	229
				26.6[b]	324	1.0	1.0	1.0	8.6	6.1	1.4	229
				26.6[b]	300	1.0	1.0	1.0	8.0	6.1	1.3	229
				26.6[b]	216	1.0	1.0	1.0	5.7	6.1	0.94	229
				26.6[b]	203	1.0	1.0	1.0	5.4	6.1	0.89	229
				26.6[b]	200	1.0	1.0	1.0	5.3	6.1	0.87	229
				26.6[b]	173	1.0	1.0	1.0	4.6	6.1	0.75	229
				26.6[b]	165	1.0	1.0	1.0	4.4	6.1	0.72	229
				26.6[b]	160	1.0	1.0	1.0	4.3	6.1	0.70	229
				26.6[b]	150	1.0	1.0	1.0	4.0	6.1	0.65	229
				26.6[b]	108	1.0	1.0	1.0	2.9	6.1	0.47	229
				26.6[b]	100	1.0	1.0	1.0	2.7	6.1	0.44	229
				26.6[b]	75	1.0	1.0	1.0	2.0	6.1	0.33	229
	Small omnivore	New sown or late season	Acute	14.4	1140	1.0	1.0	1.0	16	6.1	2.7	424
				14.4	1125	1.0	1.0	1.0	16	6.1	2.7	424
				14.4	1000	1.0	1.0	1.0	14	6.1	2.4	424
				14.4	850	1.0	1.0	1.0	12	6.1	2.0	424
				14.4	840	1.0	1.0	1.0	12	6.1	2.0	424
				14.4	750	1.0	1.0	1.0	11	6.1	1.8	424

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				14.4	600	1.0	1.0	1.0	8.6	6.1	**1.4**	424
				14.4	595	1.0	1.0	1.0	8.6	6.1	**1.4**	424
				14.4	500	1.0	1.0	1.0	7.2	6.1	**1.2**	424
				14.4	432	1.0	1.0	1.0	6.2	6.1	**1.0**	424
				14.4	400	1.0	1.0	1.0	5.8	6.1	0.94	424
				14.4	324	1.0	1.0	1.0	4.7	6.1	0.76	424
				14.4	300	1.0	1.0	1.0	4.3	6.1	0.71	424
				14.4	216	1.0	1.0	1.0	3.1	6.1	0.51	424
				14.4	203	1.0	1.0	1.0	2.9	6.1	0.48	424
				14.4	200	1.0	1.0	1.0	2.9	6.1	0.47	424
				14.4	173	1.0	1.0	1.0	2.5	6.1	0.41	424
				14.4	165	1.0	1.0	1.0	2.4	6.1	0.39	424
				14.4	160	1.0	1.0	1.0	2.3	6.1	0.38	424
				14.4	150	1.0	1.0	1.0	2.2	6.1	0.35	424
				14.4	108	1.0	1.0	1.0	1.6	6.1	0.25	424
				14.4	100	1.0	1.0	1.0	1.4	6.1	0.24	424
				14.4	75	1.0	1.0	1.0	1.1	6.1	0.18	424
	Small insectivore	Late season	Acute	5.4	1140	1.0	1.0	1.0	6.2	6.1	**1.0**	1130
				5.4	1125	1.0	1.0	1.0	6.1	6.1	1.0	1130
				5.4	1000	1.0	1.0	1.0	5.4	6.1	0.89	1130
				5.4	850	1.0	1.0	1.0	4.6	6.1	0.75	1130
				5.4	840	1.0	1.0	1.0	4.5	6.1	0.74	1130
				5.4	750	1.0	1.0	1.0	4.1	6.1	0.66	1130
				5.4	600	1.0	1.0	1.0	3.2	6.1	0.53	1130
				5.4	595	1.0	1.0	1.0	3.2	6.1	0.53	1130
				5.4	500	1.0	1.0	1.0	2.7	6.1	0.44	1130
				5.4	432	1.0	1.0	1.0	2.3	6.1	0.38	1130
				5.4	400	1.0	1.0	1.0	2.2	6.1	0.35	1130
				5.4	324	1.0	1.0	1.0	1.7	6.1	0.29	1130
				5.4	300	1.0	1.0	1.0	1.6	6.1	0.27	1130
				5.4	216	1.0	1.0	1.0	1.2	6.1	0.19	1130
				5.4	203	1.0	1.0	1.0	1.1	6.1	0.18	1130
				5.4	200	1.0	1.0	1.0	1.1	6.1	0.18	1130
				5.4	173	1.0	1.0	1.0	0.9	6.1	0.15	1130
				5.4	165	1.0	1.0	1.0	0.9	6.1	0.15	1130
				5.4	160	1.0	1.0	1.0	0.9	6.1	0.14	1130
				5.4	150	1.0	1.0	1.0	0.8	6.1	0.13	1130
				5.4	108	1.0	1.0	1.0	0.6	6.1	0.10	1130

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				5.4	100	1.0	1.0	1.0	0.5	6.1	0.09	1130
				5.4	75	1.0	1.0	1.0	0.4	6.1	0.07	1130
	Small herbivore	All season	Chronic	59.3[a]	1140	1.0	0.5	0.53	18	3.8	4.7	242
				59.3[a]	1125	1.0	0.5	0.53	18	3.8	4.7	242
				59.3[a]	1000	1.0	0.5	0.53	16	3.8	4.1	242
				59.3[a]	850	1.0	0.5	0.53	13	3.8	3.5	242
				59.3[a]	840	1.0	0.5	0.53	13	3.8	3.5	242
				59.3[a]	750	1.0	0.5	0.53	12	3.8	3.1	242
				59.3[a]	600	1.0	0.5	0.53	9.4	3.8	2.5	242
				59.3[a]	595	1.0	0.5	0.53	9.4	3.8	2.5	242
				59.3[a]	500	1.0	0.5	0.53	7.9	3.8	2.1	242
				59.3[a]	432	1.0	0.5	0.53	6.8	3.8	1.8	242
				59.3[a]	400	1.0	0.5	0.53	6.3	3.8	1.7	242
				59.3[a]	324	1.0	0.5	0.53	5.1	3.8	1.3	242
				59.3[a]	300	1.0	0.5	0.53	4.7	3.8	1.2	242
				59.3[a]	216	1.0	0.5	0.53	3.4	3.8	0.89	242
				59.3[a]	203	1.0	0.5	0.53	3.2	3.8	0.84	242
				59.3[a]	200	1.0	0.5	0.53	3.1	3.8	0.83	242
				59.3[a]	173	1.0	0.5	0.53	2.7	3.8	0.72	242
				59.3[a]	165	1.0	0.5	0.53	2.6	3.8	0.68	242
				59.3[a]	160	1.0	0.5	0.53	2.5	3.8	0.66	242
				59.3[a]	150	1.0	0.5	0.53	2.4	3.8	0.62	242
				59.3[a]	108	1.0	0.5	0.53	1.7	3.8	0.45	242
				59.3[a]	100	1.0	0.5	0.53	1.6	3.8	0.41	242
				59.3[a]	75	1.0	0.5	0.53	1.2	3.8	0.31	242
	Large herbivore	All season	Chronic	14.1[b]	1140	1.0	0.5	0.53	4.3	3.8	1.1	1017
				14.1[b]	1125	1.0	0.5	0.53	4.2	3.8	1.1	1017
				14.1[b]	1000	1.0	0.5	0.53	3.7	3.8	0.98	1017
				14.1[b]	850	1.0	0.5	0.53	3.2	3.8	0.84	1017
				14.1[b]	840	1.0	0.5	0.53	3.1	3.8	0.83	1017
				14.1[b]	750	1.0	0.5	0.53	2.8	3.8	0.74	1017
				14.1[b]	600	1.0	0.5	0.53	2.2	3.8	0.59	1017
				14.1[b]	595	1.0	0.5	0.53	2.2	3.8	0.59	1017
				14.1[b]	500	1.0	0.5	0.53	1.9	3.8	0.49	1017
				14.1[b]	432	1.0	0.5	0.53	1.6	3.8	0.42	1017
				14.1[b]	400	1.0	0.5	0.53	1.5	3.8	0.39	1017
				14.1[b]	324	1.0	0.5	0.53	1.2	3.8	0.32	1017
				14.1[b]	300	1.0	0.5	0.53	1.1	3.8	0.29	1017

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				14.1[b]	216	1.0	0.5	0.53	0.8	3.8	0.21	1017
				14.1[b]	203	1.0	0.5	0.53	0.8	3.8	0.20	1017
				14.1[b]	200	1.0	0.5	0.53	0.7	3.8	0.20	1017
				14.1[b]	173	1.0	0.5	0.53	0.6	3.8	0.17	1017
				14.1[b]	165	1.0	0.5	0.53	0.6	3.8	0.16	1017
				14.1[b]	160	1.0	0.5	0.53	0.6	3.8	0.16	1017
				14.1[b]	150	1.0	0.5	0.53	0.6	3.8	0.15	1017
				14.1[b]	108	1.0	0.5	0.53	0.4	3.8	0.11	1017
				14.1[b]	100	1.0	0.5	0.53	0.4	3.8	0.10	1017
				14.1[b]	75	1.0	0.5	0.53	0.3	3.8	0.07	1017
General weed control in lucerne (ungrazed before application)												
Legume forage	Small herbivore	BBCH ≥50	Acute	11.2[a,c]	600	1.0	1.0	1.0	6.7	6.1	1.1	545
				11.2[a,c]	595	1.0	1.0	1.0	6.7	6.1	1.1	545
				11.2[a,c]	400	1.0	1.0	1.0	4.5	6.1	0.7	545
				11.2[a,c]	300	1.0	1.0	1.0	3.4	6.1	0.6	545
General weed control in sugarcane (over the top spray and inter-row spray)												
Maize	Small herbivore	BBCH 10-29	Acute	112.0[a]	400	1.0	1.0	1.0	45	6.1	7.3	54
				112.0[a]	270	1.0	1.0	1.0	30	6.1	5.0	54
				112.0[a]	216	1.0	1.0	1.0	24	6.1	4.0	54
	Small omnivore	BBCH 10-29	Acute	17.2	400	1.0	1.0	1.0	6.9	6.1	1.1	355
				17.2	270	1.0	1.0	1.0	4.6	6.1	0.76	355
				17.2	216	1.0	1.0	1.0	3.7	6.1	0.61	355
	Small herbivore	BBCH 10-29	Chronic	59.3[a]	400	1.0	0.5	0.53	6.3	3.8	1.7	242
				59.3[a]	270	1.0	0.5	0.53	4.2	3.8	1.1	242
				59.3[a]	216	1.0	0.5	0.53	3.4	3.8	0.9	242
General weed control in bananas, dubosia, forests, orchards, plantations, tea tree												
Orchards	Small herbivore	Ground directed	Acute	112.0[a]	1120	1.0	1.0	1.0	125	6.1	21	54
				112.0[a]	810	1.0	1.0	1.0	91	6.1	15	54
				112.0[a]	600	1.0	1.0	1.0	67	6.1	11	54
				112.0[a]	500	1.0	1.0	1.0	56	6.1	9.2	54
				112.0[a]	448	1.0	1.0	1.0	50	6.1	8.2	54
				112.0[a]	432	1.0	1.0	1.0	48	6.1	7.9	54
				112.0[a]	425	1.0	1.0	1.0	48	6.1	7.8	54
				112.0[a]	330	1.0	1.0	1.0	37	6.1	6.1	54
				112.0[a]	324	1.4	1.0	1.0	51	6.1	8.3	39
				112.0[a]	324	1.0	1.0	1.0	36	6.1	5.9	54

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				112.0[a]	200	1.0	1.0	1.0	22	6.1	3.7	54
				112.0[a]	175	1.0	1.0	1.0	20	6.1	3.2	54
				112.0[a]	173	1.0	1.0	1.0	19	6.1	3.2	54
				112.0[a]	168	1.0	1.0	1.0	19	6.1	3.1	54
				112.0[a]	130	1.0	1.0	1.0	15	6.1	2.4	54
	Large herbivore	Ground directed	Acute	22.2[b]	1120	1.0	1.0	1.0	25	6.1	4.1	275
				22.2[b]	810	1.0	1.0	1.0	18	6.1	2.9	275
				22.2[b]	600	1.0	1.0	1.0	13	6.1	2.2	275
				22.2[b]	500	1.0	1.0	1.0	11	6.1	1.8	275
				22.2[b]	448	1.0	1.0	1.0	9.9	6.1	1.6	275
				22.2[b]	432	1.0	1.0	1.0	9.6	6.1	1.6	275
				22.2[b]	425	1.0	1.0	1.0	9.4	6.1	1.5	275
				22.2[b]	330	1.0	1.0	1.0	7.3	6.1	1.2	275
				22.2[b]	324	1.4	1.0	1.0	10	6.1	1.7	196
				22.2[b]	324	1.0	1.0	1.0	7.2	6.1	1.2	275
				22.2[b]	200	1.0	1.0	1.0	4.4	6.1	0.73	275
				22.2[b]	175	1.0	1.0	1.0	3.9	6.1	0.64	275
				22.2[b]	173	1.0	1.0	1.0	3.8	6.1	0.63	275
				22.2[b]	168	1.0	1.0	1.0	3.7	6.1	0.61	275
				22.2[b]	130	1.0	1.0	1.0	2.9	6.1	0.47	275
	Small omnivore	Ground directed	Acute	11.7[c]	1120	1.0	1.0	1.0	13	6.1	2.1	521
				11.7[c]	810	1.0	1.0	1.0	9.5	6.1	1.6	521
				11.7[c]	600	1.0	1.0	1.0	7.0	6.1	1.2	521
				11.7[c]	500	1.0	1.0	1.0	5.9	6.1	0.96	521
				11.7[c]	448	1.0	1.0	1.0	5.2	6.1	0.86	521
				11.7[c]	432	1.0	1.0	1.0	5.1	6.1	0.83	521
				11.7[c]	425	1.0	1.0	1.0	5.0	6.1	0.82	521
				11.7[c]	330	1.0	1.0	1.0	3.9	6.1	0.63	521
				11.7[c]	324	1.31[d]	1.0	1.0	5.0	6.1	0.81	398
				11.7[c]	324	1.0	1.0	1.0	3.8	6.1	0.62	521
				11.7[c]	200	1.0	1.0	1.0	2.3	6.1	0.38	521
				11.7[c]	175	1.0	1.0	1.0	2.0	6.1	0.34	521
				11.7[c]	173	1.0	1.0	1.0	2.0	6.1	0.33	521
				11.7[c]	168	1.0	1.0	1.0	2.0	6.1	0.32	521
				11.7[c]	130	1.0	1.0	1.0	1.5	6.1	0.25	521
	Small herbivore	Ground directed	Chronic	59.3[a]	1120	1.0	0.5	0.53	18	3.8	4.6	242
				59.3[a]	810	1.0	0.5	0.53	13	3.8	3.3	242
				59.3[a]	600	1.0	0.5	0.53	9.4	3.8	2.5	242

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				59.3[a]	500	1.0	0.5	0.53	7.9	3.8	2.1	242
				59.3[a]	448	1.0	0.5	0.53	7.0	3.8	1.9	242
				59.3[a]	432	1.0	0.5	0.53	6.8	3.8	1.8	242
				59.3[a]	425	1.0	0.5	0.53	6.7	3.8	1.8	242
				59.3[a]	330	1.0	0.5	0.53	5.2	3.8	1.4	242
				59.3[a]	324	1.4	0.5	0.53	7.1	3.8	1.9	173
				59.3[a]	324	1.0	0.5	0.53	5.1	3.8	1.3	242
				59.3[a]	200	1.0	0.5	0.53	3.1	3.8	0.83	242
				59.3[a]	175	1.0	0.5	0.53	2.8	3.8	0.72	242
				59.3[a]	173	1.0	0.5	0.53	2.7	3.8	0.72	242
				59.3[a]	168	1.0	0.5	0.53	2.6	3.8	0.69	242
				59.3[a]	130	1.0	0.5	0.53	2.0	3.8	0.54	242
General weed control in potatoes (pre-harvest)												
Potatoes	Small herbivore	BBCH ≥40	Acute	16.8[a,c]	700	1.0	1.0	1.0	12	6.1	1.9	363
				16.8[a,c]	693	1.0	1.0	1.0	12	6.1	1.9	363
				16.8[a,c]	648	1.0	1.0	1.0	11	6.1	1.8	363
				16.8[a,c]	525	1.0	1.0	1.0	8.8	6.1	1.4	363
				16.8[a,c]	432	1.0	1.0	1.0	7.3	6.1	1.2	363
				16.8[a,c]	173	1.0	1.0	1.0	2.9	6.1	0.48	363
	Large herbivore	BBCH ≥40	Acute	3.3[b,c]	700	1.0	1.0	1.0	2.3	6.1	0.38	1848
				3.3[b,c]	693	1.0	1.0	1.0	2.3	6.1	0.37	1848
				3.3[b,c]	648	1.0	1.0	1.0	2.1	6.1	0.35	1848
				3.3[b,c]	525	1.0	1.0	1.0	1.7	6.1	0.28	1848
				3.3[b,c]	432	1.0	1.0	1.0	1.4	6.1	0.23	1848
				3.3[b,c]	173	1.0	1.0	1.0	0.57	6.1	0.09	1848
	Small herbivore	BBCH ≥40	Chronic	8.9[a,c]	700	1.0	0.5	0.53	1.7	3.8	0.43	1611
				8.9[a,c]	693	1.0	0.5	0.53	1.6	3.8	0.43	1611
				8.9[a,c]	648	1.0	0.5	0.53	1.5	3.8	0.40	1611
				8.9[a,c]	525	1.0	0.5	0.53	1.2	3.8	0.33	1611
				8.9[a,c]	432	1.0	0.5	0.53	1.0	3.8	0.27	1611
				8.9[a,c]	173	1.0	0.5	0.53	0.41	3.8	0.11	1611
Spray topping in pulses												
Pulses	Small herbivore	BBCH ≥50	Acute	16.8[a,c]	200	1.0	1.0	1.0	3.4	6.1	0.6	363
				16.8[a,c]	100	1.0	1.0	1.0	1.7	6.1	0.28	363
Spray topping in pulses (field beans)												
Pulses	Small	BBCH	Acute	33.6[a,c]	200	1.0	1.0	1.0	6.7	6.1	1.1	182

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
	herbivore	≥50		33.6[a,c]	100	1.0	1.0	1.0	3.4	6.1	0.55	182
General weed control in vineyards												
Vineyards	Small herbivore	Ground directed	Acute	112.0[a]	1120	1.0	1.0	1.0	125	6.1	**21**	54
				112.0[a]	810	1.0	1.0	1.0	91	6.1	**15**	54
				112.0[a]	600	1.0	1.0	1.0	67	6.1	**11**	54
				112.0[a]	500	1.0	1.0	1.0	56	6.1	**9.2**	54
				112.0[a]	448	1.0	1.0	1.0	50	6.1	**8.2**	54
				112.0[a]	432	1.0	1.0	1.0	48	6.1	**7.9**	54
				112.0[a]	420	1.0	1.0	1.0	47	6.1	**7.7**	54
				112.0[a]	330	1.0	1.0	1.0	37	6.1	**6.1**	54
				112.0[a]	324	1.0	1.0	1.0	36	6.1	**5.9**	54
				112.0[a]	200	1.0	1.0	1.0	22	6.1	**3.7**	54
				112.0[a]	173	1.0	1.0	1.0	19	6.1	**3.2**	54
				112.0[a]	170	1.0	1.0	1.0	19	6.1	**3.1**	54
	Large herbivore	Ground directed	Acute	22.2[b]	1120	1.0	1.0	1.0	25	6.1	**4.1**	275
				22.2[b]	810	1.0	1.0	1.0	18	6.1	**2.9**	275
				22.2[b]	600	1.0	1.0	1.0	13	6.1	**2.2**	275
				22.2[b]	500	1.0	1.0	1.0	11	6.1	**1.8**	275
				22.2[b]	448	1.0	1.0	1.0	9.9	6.1	**1.6**	275
				22.2[b]	432	1.0	1.0	1.0	9.6	6.1	**1.6**	275
				22.2[b]	420	1.0	1.0	1.0	9.3	6.1	**1.5**	275
				22.2[b]	330	1.0	1.0	1.0	7.3	6.1	**1.2**	275
				22.2[b]	324	1.0	1.0	1.0	7.2	6.1	**1.2**	275
				22.2[b]	200	1.0	1.0	1.0	4.4	6.1	0.73	275
				22.2[b]	173	1.0	1.0	1.0	3.8	6.1	0.63	275
				22.2[b]	170	1.0	1.0	1.0	3.8	6.1	0.62	275
	Small omnivore	Ground directed	Acute	11.7[c]	1120	1.0	1.0	1.0	13	6.1	**2.1**	521
				11.7[c]	810	1.0	1.0	1.0	9.5	6.1	**1.6**	521
				11.7[c]	600	1.0	1.0	1.0	7.0	6.1	**1.2**	521
				11.7[c]	500	1.0	1.0	1.0	5.9	6.1	0.96	521
				11.7[c]	448	1.0	1.0	1.0	5.2	6.1	0.86	521
				11.7[c]	432	1.0	1.0	1.0	5.1	6.1	0.83	521
				11.7[c]	420	1.0	1.0	1.0	4.9	6.1	0.81	521
				11.7[c]	330	1.0	1.0	1.0	3.9	6.1	0.63	521
				11.7[c]	324	1.0	1.0	1.0	3.8	6.1	0.62	521
				11.7[c]	200	1.0	1.0	1.0	2.3	6.1	0.38	521
				11.7[c]	173	1.0	1.0	1.0	2.0	6.1	0.33	521

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				11.7[c]	170	1.0	1.0	1.0	2.0	6.1	0.33	521
	Small herbivore	Ground directed	Chronic	59.3[a]	1120	1.0	0.5	0.53	17.6	3.8	4.6	242
				59.3[a]	810	1.0	0.5	0.53	12.7	3.8	3.3	242
				59.3[a]	600	1.0	0.5	0.53	9.4	3.8	2.5	242
				59.3[a]	500	1.0	0.5	0.53	7.9	3.8	2.1	242
				59.3[a]	448	1.0	0.5	0.53	7.0	3.8	1.9	242
				59.3[a]	432	1.0	0.5	0.53	6.8	3.8	1.8	242
				59.3[a]	420	1.0	0.5	0.53	6.6	3.8	1.7	242
				59.3[a]	330	1.0	0.5	0.53	5.2	3.8	1.4	242
				59.3[a]	324	1.0	0.5	0.53	5.1	3.8	1.3	242
				59.3[a]	200	1.0	0.5	0.53	3.1	3.8	0.83	242
				59.3[a]	173	1.0	0.5	0.53	2.7	3.8	0.72	242
				59.3[a]	170	1.0	0.5	0.53	2.7	3.8	0.70	242

[a] Refined shortcut value used for risk assessment; small herbivores, bodyweight adjusted to 50 g
[b] Refined shortcut value used for risk assessment; large herbivores, bodyweight adjusted to 1500 g and DEE based on non-eutherian mammals
[c] Refined shortcut value used for risk assessment; adjusted for interception values in EFSA (2020)
[d] Value (MAF or TWA) adjusted to account for DT_{50} 4.6 d for arthropod food items
Crop groups and situations as indicated in Table 74
Generic focal species and shortcut values for indicated crop groups from EFSA (2009), unless indicated otherwise
AR (g ac/ha) = application rate, the values quoted have been adjusted for FFT (from Table 74)
MAF = multiple application factor
PT = proportion of daily diet obtained treated area (acute 1.0, chronic 0.5)
TWA = time weighted average factor
DDD (mg ac/kg bw or mg ac/kg bw/d) = daily dietary dose = AR ⁄ 1000 × shortcut value × MAF × PT × TWA
RAL = regulatory acceptable level
Acute = geomean LD_{50} 61 mg/kg bw (Duerden 1994, Farnworth et al. 1993, Fletcher 1967, Heylings & Farnworth 1992, Kimbrough & Gaines 1970, Murray & Gibson 1972) and assessment factor of 10
Chronic = NOAEL 3.8 mg/kg bw/d (Lindsay 1982a, 1982b) and assessment factor of 1
RQ = risk quotient = DDD ⁄ RAL, RQ ≤1 indicates an acceptable risk
Max rate (g ac/ha) = maximum acceptable rate, per application = RAL × 1000 / (shortcut value × MAF × PT × TWA)

Table 78: Refined assessment of risks to birds (acute RAL 5.7 mg/kg bw; chronic 2.7 mg ac/kg bw/d)

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
General weed control in fallow (including minimal/full disturbance, and optical spot spraying), hops, market gardens, nurseries, row crops, potatoes (pre/early emergence), rice (pre/post sowing), vegetables												
Bare soil	Small granivore	BBCH <10	Acute	24.7	1505	1.0	1.0	1.0	37	5.7	6.5	231
				24.7	675	1.0	1.0	1.0	17	5.7	2.9	231
				24.7	600	1.0	1.0	1.0	15	5.7	2.6	231
				24.7	595	1.0	1.0	1.0	15	5.7	2.6	231
				24.7	525	1.0	1.0	1.0	13	5.7	2.3	231
				24.7	510	1.0	1.0	1.0	13	5.7	2.2	231

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				24.7	504	1.0	1.0	1.0	12	5.7	2.2	231
				24.7	500	1.0	1.0	1.0	12	5.7	2.2	231
				24.7	450	1.0	1.0	1.0	11	5.7	2.0	231
				24.7	432	1.6	1.0	1.0	17	5.7	3.0	144
				24.7	432	1.0	1.0	1.0	11	5.7	1.9	231
				24.7	400	1.0	1.0	1.0	9.9	5.7	1.7	231
				24.7	390	1.0	1.0	1.0	9.6	5.7	1.7	231
				24.7	375	1.0	1.0	1.0	9.3	5.7	1.6	231
				24.7	350	1.0	1.0	1.0	8.6	5.7	1.5	231
				24.7	324	1.6	1.0	1.0	13	5.7	2.2	144
				24.7	324	1.0	1.0	1.0	8.0	5.7	1.4	231
				24.7	300	1.0	1.0	1.0	7.4	5.7	1.3	231
				24.7	243	1.0	1.0	1.0	6.0	5.7	1.1	231
				24.7	216	1.6	1.0	1.0	8.5	5.7	1.5	144
				24.7	216	1.0	1.0	1.0	5.3	5.7	0.94	231
				24.7	200	1.0	1.0	1.0	4.9	5.7	0.87	231
				24.7	188	1.0	1.0	1.0	4.6	5.7	0.81	231
				24.7	185	1.0	1.0	1.0	4.6	5.7	0.80	231
				24.7	173	1.0	1.0	1.0	4.3	5.7	0.75	231
				24.7	162	1.6	1.0	1.0	6.4	5.7	1.1	144
				24.7	162	1.0	1.0	1.0	4.0	5.7	0.70	231
				24.7	150	1.0	1.0	1.0	3.7	5.7	0.65	231
				24.7	113	1.0	1.0	1.0	2.8	5.7	0.49	231
				24.7	108	1.0	1.0	1.0	2.7	5.7	0.47	231
	Small omnivore	BBCH <10	Acute	17.4	1505	1.0	1.0	1.0	26	5.7	4.6	328
				17.4	700	1.0	1.0	1.0	12	5.7	2.1	328
				17.4	675	1.0	1.0	1.0	12	5.7	2.1	328
				17.4	648	1.0	1.0	1.0	11	5.7	2.0	328
				17.4	600	1.0	1.0	1.0	10	5.7	1.8	328
				17.4	595	1.0	1.0	1.0	10	5.7	1.8	328
				17.4	525	1.0	1.0	1.0	9.1	5.7	1.6	328
				17.4	510	1.0	1.0	1.0	8.9	5.7	1.6	328
				17.4	504	1.0	1.0	1.0	8.8	5.7	1.5	328
				17.4	500	1.0	1.0	1.0	8.7	5.7	1.5	328
				17.4	450	1.0	1.0	1.0	7.8	5.7	1.4	328
				17.4	432	1.48[a]	1.0	1.0	11	5.7	2.0	221
				17.4	432	1.0	1.0	1.0	7.5	5.7	1.3	328
				17.4	400	1.0	1.0	1.0	7.0	5.7	1.2	328

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				17.4	390	1.0	1.0	1.0	6.8	5.7	1.2	328
				17.4	375	1.0	1.0	1.0	6.5	5.7	1.1	328
				17.4	350	1.0	1.0	1.0	6.1	5.7	1.1	328
				17.4	324	1.48[a]	1.0	1.0	8.3	5.7	1.5	221
				17.4	324	1.0	1.0	1.0	5.6	5.7	0.99	328
				17.4	300	1.0	1.0	1.0	5.2	5.7	0.92	328
				17.4	243	1.0	1.0	1.0	4.2	5.7	0.74	328
				17.4	216	1.48[a]	1.0	1.0	5.6	5.7	0.98	221
				17.4	216	1.0	1.0	1.0	3.8	5.7	0.66	328
				17.4	200	1.0	1.0	1.0	3.5	5.7	0.61	328
				17.4	188	1.0	1.0	1.0	3.3	5.7	0.57	328
				17.4	185	1.0	1.0	1.0	3.2	5.7	0.56	328
				17.4	173	1.0	1.0	1.0	3.0	5.7	0.53	328
				17.4	162	1.48[a]	1.0	1.0	4.2	5.7	0.73	221
				17.4	162	1.0	1.0	1.0	2.8	5.7	0.49	328
				17.4	150	1.0	1.0	1.0	2.6	5.7	0.46	328
				17.4	113	1.0	1.0	1.0	2.0	5.7	0.34	328
				17.4	108	1.0	1.0	1.0	1.9	5.7	0.33	328
	Small insectivore	BBCH <10	Acute	10.9	1505	1.0	1.0	1.0	16	5.7	2.9	523
				10.9	700	1.0	1.0	1.0	7.6	5.7	1.3	523
				10.9	675	1.0	1.0	1.0	7.4	5.7	1.3	523
				10.9	648	1.0	1.0	1.0	7.1	5.7	1.2	523
				10.9	600	1.0	1.0	1.0	6.5	5.7	1.1	523
				10.9	595	1.0	1.0	1.0	6.5	5.7	1.1	523
				10.9	525	1.0	1.0	1.0	5.7	5.7	1.0	523
				10.9	510	1.0	1.0	1.0	5.6	5.7	0.98	523
				10.9	504	1.0	1.0	1.0	5.5	5.7	0.96	523
				10.9	500	1.0	1.0	1.0	5.5	5.7	0.96	523
				10.9	450	1.0	1.0	1.0	4.9	5.7	0.86	523
				10.9	432	1.3[a]	1.0	1.0	6.1	5.7	1.1	402
				10.9	432	1.0	1.0	1.0	4.7	5.7	0.83	523
				10.9	400	1.0	1.0	1.0	4.4	5.7	0.76	523
				10.9	390	1.0	1.0	1.0	4.3	5.7	0.75	523
				10.9	375	1.0	1.0	1.0	4.1	5.7	0.72	523
				10.9	350	1.0	1.0	1.0	3.8	5.7	0.67	523
				10.9	324	1.3[a]	1.0	1.0	4.6	5.7	0.81	402
				10.9	324	1.0	1.0	1.0	3.5	5.7	0.62	523
				10.9	300	1.0	1.0	1.0	3.3	5.7	0.57	523

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				10.9	243	1.0	1.0	1.0	2.6	5.7	0.46	523
				10.9	216	1.3[a]	1.0	1.0	3.1	5.7	0.54	402
				10.9	216	1.0	1.0	1.0	2.4	5.7	0.41	523
				10.9	200	1.0	1.0	1.0	2.2	5.7	0.38	523
				10.9	188	1.0	1.0	1.0	2.0	5.7	0.36	523
				10.9	185	1.0	1.0	1.0	2.0	5.7	0.35	523
				10.9	173	1.0	1.0	1.0	1.9	5.7	0.33	523
				10.9	162	1.3[a]	1.0	1.0	2.3	5.7	0.40	402
				10.9	162	1.0	1.0	1.0	1.8	5.7	0.31	523
				10.9	150	1.0	1.0	1.0	1.6	5.7	0.29	523
				10.9	113	1.0	1.0	1.0	1.2	5.7	0.22	523
				10.9	108	1.0	1.0	1.0	1.2	5.7	0.21	523
General weed control in industrial vegetation management, pasture, public service areas, rights of way												
Grassland	Small granivore	Late season	Acute	24.7	1140	1.0	1.0	1.0	28	5.7	**4.9**	231
				24.7	1125	1.0	1.0	1.0	28	5.7	**4.9**	231
				24.7	1000	1.0	1.0	1.0	25	5.7	**4.3**	231
				24.7	850	1.0	1.0	1.0	21	5.7	**3.7**	231
				24.7	840	1.0	1.0	1.0	21	5.7	**3.6**	231
				24.7	750	1.0	1.0	1.0	19	5.7	**3.3**	231
				24.7	600	1.0	1.0	1.0	15	5.7	**2.6**	231
				24.7	595	1.0	1.0	1.0	15	5.7	**2.6**	231
				24.7	500	1.0	1.0	1.0	12	5.7	**2.2**	231
				24.7	432	1.0	1.0	1.0	11	5.7	**1.9**	231
				24.7	400	1.0	1.0	1.0	9.9	5.7	**1.7**	231
				24.7	324	1.0	1.0	1.0	8.0	5.7	**1.4**	231
				24.7	300	1.0	1.0	1.0	7.4	5.7	**1.3**	231
				24.7	216	1.0	1.0	1.0	5.3	5.7	0.94	231
				24.7	203	1.0	1.0	1.0	5.0	5.7	0.88	231
				24.7	200	1.0	1.0	1.0	4.9	5.7	0.87	231
				24.7	173	1.0	1.0	1.0	4.3	5.7	0.75	231
				24.7	165	1.0	1.0	1.0	4.1	5.7	0.72	231
				24.7	160	1.0	1.0	1.0	4.0	5.7	0.69	231
				24.7	150	1.0	1.0	1.0	3.7	5.7	0.65	231
				24.7	108	1.0	1.0	1.0	2.7	5.7	0.47	231
				24.7	100	1.0	1.0	1.0	2.5	5.7	0.43	231
				24.7	75	1.0	1.0	1.0	1.9	5.7	0.33	231
	Large	Growing	Acute	30.5	1140	1.0	1.0	1.0	35	5.7	**6.1**	187

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
	herbivore	shoots		30.5	1125	1.0	1.0	1.0	34	5.7	6.0	187
				30.5	1000	1.0	1.0	1.0	31	5.7	5.4	187
				30.5	850	1.0	1.0	1.0	26	5.7	4.5	187
				30.5	840	1.0	1.0	1.0	26	5.7	4.5	187
				30.5	750	1.0	1.0	1.0	23	5.7	4.0	187
				30.5	600	1.0	1.0	1.0	18	5.7	3.2	187
				30.5	595	1.0	1.0	1.0	18	5.7	3.2	187
				30.5	500	1.0	1.0	1.0	15	5.7	2.7	187
				30.5	432	1.0	1.0	1.0	13	5.7	2.3	187
				30.5	400	1.0	1.0	1.0	12	5.7	2.1	187
				30.5	324	1.0	1.0	1.0	9.9	5.7	1.7	187
				30.5	300	1.0	1.0	1.0	9.2	5.7	1.6	187
				30.5	216	1.0	1.0	1.0	6.6	5.7	1.2	187
				30.5	203	1.0	1.0	1.0	6.2	5.7	1.1	187
				30.5	200	1.0	1.0	1.0	6.1	5.7	1.1	187
				30.5	173	1.0	1.0	1.0	5.3	5.7	0.93	187
				30.5	165	1.0	1.0	1.0	5.0	5.7	0.88	187
				30.5	160	1.0	1.0	1.0	4.9	5.7	0.86	187
				30.5	150	1.0	1.0	1.0	4.6	5.7	0.80	187
				30.5	108	1.0	1.0	1.0	3.3	5.7	0.58	187
				30.5	100	1.0	1.0	1.0	3.1	5.7	0.54	187
				30.5	75	1.0	1.0	1.0	2.3	5.7	0.40	187
	Small insectivore	Growing shoots	Acute	26.8	1140	1.0	1.0	1.0	31	5.7	5.4	213
				26.8	1125	1.0	1.0	1.0	30	5.7	5.3	213
				26.8	1000	1.0	1.0	1.0	27	5.7	4.7	213
				26.8	850	1.0	1.0	1.0	23	5.7	4.0	213
				26.8	840	1.0	1.0	1.0	23	5.7	3.9	213
				26.8	750	1.0	1.0	1.0	20	5.7	3.5	213
				26.8	600	1.0	1.0	1.0	16	5.7	2.8	213
				26.8	595	1.0	1.0	1.0	16	5.7	2.8	213
				26.8	500	1.0	1.0	1.0	13	5.7	2.4	213
				26.8	432	1.0	1.0	1.0	12	5.7	2.0	213
				26.8	400	1.0	1.0	1.0	11	5.7	1.9	213
				26.8	324	1.0	1.0	1.0	8.7	5.7	1.5	213
				26.8	300	1.0	1.0	1.0	8.0	5.7	1.4	213
				26.8	216	1.0	1.0	1.0	5.8	5.7	1.0	213
				26.8	203	1.0	1.0	1.0	5.4	5.7	0.95	213
				26.8	200	1.0	1.0	1.0	5.4	5.7	0.94	213

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				26.8	173	1.0	1.0	1.0	4.6	5.7	0.81	213
				26.8	165	1.0	1.0	1.0	4.4	5.7	0.78	213
				26.8	160	1.0	1.0	1.0	4.3	5.7	0.75	213
				26.8	150	1.0	1.0	1.0	4.0	5.7	0.71	213
				26.8	108	1.0	1.0	1.0	2.9	5.7	0.51	213
				26.8	100	1.0	1.0	1.0	2.7	5.7	0.47	213
				26.8	75	1.0	1.0	1.0	2.0	5.7	0.35	213
	Small granivore	Late season	Chronic	11.4	1140	1.0	0.5	0.53	3.4	2.7	1.3	894
				11.4	1125	1.0	0.5	0.53	3.4	2.7	1.3	894
				11.4	1000	1.0	0.5	0.53	3.0	2.7	1.1	894
				11.4	850	1.0	0.5	0.53	2.6	2.7	0.95	894
				11.4	840	1.0	0.5	0.53	2.5	2.7	0.94	894
				11.4	750	1.0	0.5	0.53	2.3	2.7	0.84	894
				11.4	600	1.0	0.5	0.53	1.8	2.7	0.67	894
				11.4	595	1.0	0.5	0.53	1.8	2.7	0.67	894
				11.4	500	1.0	0.5	0.53	1.5	2.7	0.56	894
				11.4	432	1.0	0.5	0.53	1.3	2.7	0.48	894
				11.4	400	1.0	0.5	0.53	1.2	2.7	0.45	894
				11.4	324	1.0	0.5	0.53	0.98	2.7	0.36	894
				11.4	300	1.0	0.5	0.53	0.91	2.7	0.34	894
				11.4	216	1.0	0.5	0.53	0.65	2.7	0.24	894
				11.4	203	1.0	0.5	0.53	0.61	2.7	0.23	894
				11.4	200	1.0	0.5	0.53	0.60	2.7	0.22	894
				11.4	173	1.0	0.5	0.53	0.52	2.7	0.19	894
				11.4	165	1.0	0.5	0.53	0.50	2.7	0.18	894
				11.4	160	1.0	0.5	0.53	0.48	2.7	0.18	894
				11.4	150	1.0	0.5	0.53	0.45	2.7	0.17	894
				11.4	108	1.0	0.5	0.53	0.33	2.7	0.12	894
				11.4	100	1.0	0.5	0.53	0.30	2.7	0.11	894
				11.4	75	1.0	0.5	0.53	0.23	2.7	0.08	894
	Large herbivore	Growing shoots	Chronic	16.2	1140	1.0	0.5	0.53	4.9	2.7	1.8	629
				16.2	1125	1.0	0.5	0.53	4.8	2.7	1.8	629
				16.2	1000	1.0	0.5	0.53	4.3	2.7	1.6	629
				16.2	850	1.0	0.5	0.53	3.6	2.7	1.4	629
				16.2	840	1.0	0.5	0.53	3.6	2.7	1.3	629
				16.2	750	1.0	0.5	0.53	3.2	2.7	1.2	629
				16.2	600	1.0	0.5	0.53	2.6	2.7	0.95	629
				16.2	595	1.0	0.5	0.53	2.6	2.7	0.95	629

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				16.2	500	1.0	0.5	0.53	2.1	2.7	0.80	629
				16.2	432	1.0	0.5	0.53	1.9	2.7	0.69	629
				16.2	400	1.0	0.5	0.53	1.7	2.7	0.64	629
				16.2	324	1.0	0.5	0.53	1.4	2.7	0.52	629
				16.2	300	1.0	0.5	0.53	1.3	2.7	0.48	629
				16.2	216	1.0	0.5	0.53	0.93	2.7	0.34	629
				16.2	203	1.0	0.5	0.53	0.87	2.7	0.32	629
				16.2	200	1.0	0.5	0.53	0.86	2.7	0.32	629
				16.2	173	1.0	0.5	0.53	0.74	2.7	0.28	629
				16.2	165	1.0	0.5	0.53	0.71	2.7	0.26	629
				16.2	160	1.0	0.5	0.53	0.69	2.7	0.25	629
				16.2	150	1.0	0.5	0.53	0.64	2.7	0.24	629
				16.2	108	1.0	0.5	0.53	0.46	2.7	0.17	629
				16.2	100	1.0	0.5	0.53	0.43	2.7	0.16	629
				16.2	75	1.0	0.5	0.53	0.32	2.7	0.12	629
	Small insectivore	Growing shoots	Chronic	11.3	1140	1.0	0.5	0.30[a]	1.9	2.7	0.72	1593
				11.3	1125	1.0	0.5	0.30[a]	1.9	2.7	0.71	1593
				11.3	1000	1.0	0.5	0.30[a]	1.7	2.7	0.63	1593
				11.3	850	1.0	0.5	0.30[a]	1.4	2.7	0.53	1593
				11.3	840	1.0	0.5	0.30[a]	1.4	2.7	0.53	1593
				11.3	750	1.0	0.5	0.30[a]	1.3	2.7	0.47	1593
				11.3	600	1.0	0.5	0.30[a]	1.0	2.7	0.38	1593
				11.3	595	1.0	0.5	0.30[a]	1.0	2.7	0.37	1593
				11.3	500	1.0	0.5	0.30[a]	0.85	2.7	0.31	1593
				11.3	432	1.0	0.5	0.30[a]	0.73	2.7	0.27	1593
				11.3	400	1.0	0.5	0.30[a]	0.68	2.7	0.25	1593
				11.3	324	1.0	0.5	0.30[a]	0.55	2.7	0.20	1593
				11.3	300	1.0	0.5	0.30[a]	0.51	2.7	0.19	1593
				11.3	216	1.0	0.5	0.30[a]	0.37	2.7	0.14	1593
				11.3	203	1.0	0.5	0.30[a]	0.34	2.7	0.13	1593
				11.3	200	1.0	0.5	0.30[a]	0.34	2.7	0.13	1593
				11.3	173	1.0	0.5	0.30[a]	0.29	2.7	0.11	1593
				11.3	165	1.0	0.5	0.30[a]	0.28	2.7	0.10	1593
				11.3	160	1.0	0.5	0.30[a]	0.27	2.7	0.10	1593
				11.3	150	1.0	0.5	0.30[a]	0.25	2.7	0.09	1593
				11.3	108	1.0	0.5	0.30[a]	0.18	2.7	0.07	1593
				11.3	100	1.0	0.5	0.30[a]	0.17	2.7	0.06	1593
				11.3	75	1.0	0.5	0.30[a]	0.13	2.7	0.05	1593

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
General weed control in lucerne (ungrazed before application)												
Legume forage	Small insectivore	BBCH ≥20	Acute	25.2	600	1.0	1.0	1.0	15	5.7	2.7	226
				25.2	595	1.0	1.0	1.0	15	5.7	2.6	226
				25.2	400	1.0	1.0	1.0	10	5.7	1.8	226
				25.2	300	1.0	1.0	1.0	7.6	5.7	1.3	226
General weed control in peanuts (BBCH 10-19), lucerne (grazed before application)												
Legume forage	Small granivore	BBCH 10-49	Acute	24.7	324	1.0	1.0	1.0	8.0	5.7	1.4	231
				24.7	250	1.0	1.0	1.0	6.2	5.7	1.1	231
				24.7	216	1.0	1.0	1.0	5.3	5.7	0.94	231
				24.7	200	1.0	1.0	1.0	4.9	5.7	0.87	231
				24.7	150	1.0	1.0	1.0	3.7	5.7	0.65	231
				24.7	100	1.0	1.0	1.0	2.5	5.7	0.43	231
	Small omnivore	BBCH 10-49	Acute	24.0	324	1.0	1.0	1.0	7.8	5.7	1.4	238
				24.0	250	1.0	1.0	1.0	6.0	5.7	1.1	238
				24.0	216	1.0	1.0	1.0	5.2	5.7	0.91	238
				24.0	200	1.0	1.0	1.0	4.8	5.7	0.84	238
				24.0	150	1.0	1.0	1.0	3.6	5.7	0.63	238
				24.0	100	1.0	1.0	1.0	2.4	5.7	0.42	238
	Small insectivore	BBCH 10-19	Acute	26.8	324	1.0	1.0	1.0	8.7	5.7	1.5	213
				26.8	250	1.0	1.0	1.0	6.7	5.7	1.2	213
				26.8	216	1.0	1.0	1.0	5.8	5.7	1.0	213
				26.8	200	1.0	1.0	1.0	5.4	5.7	0.94	213
				26.8	150	1.0	1.0	1.0	4.0	5.7	0.71	213
				26.8	100	1.0	1.0	1.0	2.7	5.7	0.47	213
General weed control in sugarcane (over the top spray)												
Maize	Medium herbivore/ granivore	BBCH 10-29	Acute	41.7[b]	400	1.0	1.0	1.0	17	5.7	2.9	137
				41.7[b]	270	1.0	1.0	1.0	11	5.7	2.0	137
				41.7[b]	216	1.0	1.0	1.0	9.0	5.7	1.6	137
	Small omnivore	BBCH 10-29	Acute	18.1[b]	400	1.0	1.0	1.0	7.2	5.7	1.3	315
				18.1[b]	270	1.0	1.0	1.0	4.9	5.7	0.86	315
				18.1[b]	216	1.0	1.0	1.0	3.9	5.7	0.69	315
	Small insectivore	BBCH 10-19	Acute	18.9[b]	400	1.0	1.0	1.0	7.6	5.7	1.3	302
				18.9[b]	270	1.0	1.0	1.0	5.1	5.7	0.90	302
				18.9[b]	216	1.0	1.0	1.0	4.1	5.7	0.72	302

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
General weed control in sugarcane (inter-row spray)												
Maize	Medium herbivore/ granivore	BBCH 10-29	Acute	55.6	400	1.0	1.0	1.0	22	5.7	3.9	103
				55.6	270	1.0	1.0	1.0	15	5.7	2.6	103
				55.6	216	1.0	1.0	1.0	12	5.7	2.1	103
	Small omnivore	BBCH 10-29	Acute	24.0	400	1.0	1.0	1.0	9.6	5.7	1.7	238
				24.0	270	1.0	1.0	1.0	6.5	5.7	1.1	238
				24.0	216	1.0	1.0	1.0	5.2	5.7	0.91	238
	Small insectivore	BBCH 10-19	Acute	26.8	400	1.0	1.0	1.0	11	5.7	1.9	213
				26.8	270	1.0	1.0	1.0	7.2	5.7	1.3	213
				26.8	216	1.0	1.0	1.0	5.8	5.7	1.0	213
General weed control in bananas, dubosia, forests, orchards, plantations, tea tree, vineyards												
Orchards	Small granivore	Ground directed	Acute	15.1[b]	1120	1.0	1.0	1.0	17	5.7	3.0	377
				15.1[b]	810	1.0	1.0	1.0	12	5.7	2.1	377
				15.1[b]	600	1.0	1.0	1.0	9.1	5.7	1.6	377
				15.1[b]	500	1.0	1.0	1.0	7.6	5.7	1.3	377
				15.1[b]	448	1.0	1.0	1.0	6.8	5.7	1.2	377
				15.1[b]	432	1.0	1.0	1.0	6.5	5.7	1.1	377
				15.1[b]	425	1.0	1.0	1.0	6.4	5.7	1.1	377
				15.1[b]	420	1.0	1.0	1.0	6.3	5.7	1.1	377
				15.1[b]	330	1.0	1.0	1.0	5.0	5.7	0.87	377
				15.1[b]	324	1.4	1.0	1.0	6.8	5.7	1.2	270
				15.1[b]	324	1.0	1.0	1.0	4.9	5.7	0.86	377
				15.1[b]	200	1.0	1.0	1.0	3.0	5.7	0.53	377
				15.1[b]	175	1.0	1.0	1.0	2.6	5.7	0.46	377
				15.1[b]	173	1.0	1.0	1.0	2.6	5.7	0.46	377
				15.1[b]	170	1.0	1.0	1.0	2.6	5.7	0.45	377
				15.1[b]	168	1.0	1.0	1.0	2.5	5.7	0.45	377
				15.1[b]	130	1.0	1.0	1.0	2.0	5.7	0.34	377
	Small insectivore/ worm feeding	Ground directed	Acute	7.4	1120	1.0	1.0	1.0	8.3	5.7	1.5	770
				7.4	810	1.0	1.0	1.0	6.0	5.7	1.1	770
				7.4	600	1.0	1.0	1.0	4.4	5.7	0.78	770
				7.4	500	1.0	1.0	1.0	3.7	5.7	0.65	770
				7.4	448	1.0	1.0	1.0	3.3	5.7	0.58	770
				7.4	432	1.0	1.0	1.0	3.2	5.7	0.56	770
				7.4	425	1.0	1.0	1.0	3.1	5.7	0.55	770
				7.4	420	1.0	1.0	1.0	3.1	5.7	0.55	770
				7.4	330	1.0	1.0	1.0	2.4	5.7	0.43	770

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				7.4	324	1.1[a]	1.0	1.0	2.6	5.7	0.46	700
				7.4	324	1.0	1.0	1.0	2.4	5.7	0.42	770
				7.4	200	1.0	1.0	1.0	1.5	5.7	0.26	770
				7.4	175	1.0	1.0	1.0	1.3	5.7	0.23	770
				7.4	173	1.0	1.0	1.0	1.3	5.7	0.22	770
				7.4	170	1.0	1.0	1.0	1.3	5.7	0.22	770
				7.4	168	1.0	1.0	1.0	1.2	5.7	0.22	770
				7.4	130	1.0	1.0	1.0	0.96	5.7	0.17	770
	Small granivore	Ground directed	Chronic	7.0[b]	1120	1.0	0.5	0.53	2.1	2.7	0.77	1456
				7.0[b]	810	1.0	0.5	0.53	1.5	2.7	0.56	1456
				7.0[b]	600	1.0	0.5	0.53	1.1	2.7	0.41	1456
				7.0[b]	500	1.0	0.5	0.53	0.93	2.7	0.34	1456
				7.0[b]	448	1.0	0.5	0.53	0.83	2.7	0.31	1456
				7.0[b]	432	1.0	0.5	0.53	0.80	2.7	0.30	1456
				7.0[b]	425	1.0	0.5	0.53	0.79	2.7	0.29	1456
				7.0[b]	420	1.0	0.5	0.53	0.78	2.7	0.29	1456
				7.0[b]	330	1.0	0.5	0.53	0.61	2.7	0.23	1456
				7.0[b]	324	1.4	0.5	0.53	0.84	2.7	0.31	1040
				7.0[b]	324	1.0	0.5	0.53	0.60	2.7	0.22	1456
				7.0[b]	200	1.0	0.5	0.53	0.37	2.7	0.14	1456
				7.0[b]	175	1.0	0.5	0.53	0.32	2.7	0.12	1456
				7.0[b]	173	1.0	0.5	0.53	0.32	2.7	0.12	1456
				7.0[b]	170	1.0	0.5	0.53	0.32	2.7	0.12	1456
				7.0[b]	168	1.0	0.5	0.53	0.31	2.7	0.12	1456
				7.0[b]	130	1.0	0.5	0.53	0.24	2.7	0.09	1456
General weed control in potatoes (pre-harvest)												
Potatoes	Small insectivore	BBCH ≥20	Acute	25.2	700	1.0	1.0	1.0	18	5.7	3.1	226
				25.2	693	1.0	1.0	1.0	17	5.7	3.1	226
				25.2	648	1.0	1.0	1.0	16	5.7	2.9	226
				25.2	525	1.0	1.0	1.0	13	5.7	2.3	226
				25.2	432	1.0	1.0	1.0	11	5.7	1.9	226
				25.2	173	1.0	1.0	1.0	4.4	5.7	0.76	226

[a] Value (MAF or TWA) adjusted to account for DT_{50} 4.6 d for arthropod food items
[b] Refined shortcut value used for risk assessment; adjusted for interception values in EFSA (2020)
Crop groups and situations as indicated in Table 74
Generic focal species and shortcut values for indicated crop groups from EFSA (2009), unless indicated otherwise
AR (g ac/ha) = application rate, the values quoted have been adjusted for FFT (from Table 74)
MAF = multiple application factor
PT = proportion of daily diet obtained treated area (acute 1.0, chronic 0.5)
TWA = time weighted average factor
DDD (mg ac/kg bw or mg ac/kg bw/d) = daily dietary dose = AR ⁄ 1000 × shortcut value × MAF × PT × TWA

RAL = regulatory acceptable level
Acute = geomean LD_{50} 57 mg/kg bw (Fink et al. 1979, Hubbard et al. 2014 and Johnson 1998) and assessment factor of 10
Chronic = NOEL 2.7 mg/kg bw/d (Fink et al. 1982) and assessment factor of 1
RQ = risk quotient = DDD ⁄ RAL, RQ ≤1 indicates an acceptable risk
Max rate (g ac/ha) = maximum acceptable rate, per application = RAL × 1000 / (shortcut value × MAF × PT × TWA)

Weight-of-evidence discussion

It is acknowledged that uncertainties are inherent in the risk assessment scheme in general and in Tier 1 assessments. These issues are discussed in EFSA (2023) (Sections 13.1.2 and 13.2); that summary is useful, but differences in risk assessment between EFSA (2023) and EFSA (2009) should also be kept in mind. The discussion has not been reproduced here, but to greater or lesser extent, is relevant to the current assessment.

There are additional observations that are relevant to the assessment of paraquat that have not or cannot currently be accounted for in the quantitative risk assessment. A summary of these issues relevant to the risk assessment for paraquat is included in Table 79. These sources of uncertainty are not specific to a particular crop and are applicable to all, or many uses. Issues related to specific crops/uses and qualitative data submitted to support those risk assessments has been considered below the table under the relevant heading.

Table 79: Sources of uncertainty relevant to a weight of evidence argument

Source of uncertainty	Relevant taxa	Discussion
Acute dietary exposure	Birds	The available dietary exposure study (Hill et al. 1975) is not considered suitable to determine a regulatory acceptable level when expressed as a dose (mg ac/kg bw). However, as implied by this study, it is possible that dietary exposure would result in lower levels of exposure than predicted by the current assumptions of the quantitative risk assessment. Reliable confirmatory experimental information would be required to establish what magnitude of effect occurs.
	Mammals	Theoretically there may be a difference between dietary and oral dosing. The results reported in Linder & Richmond (1990) imply this could be the case (5d LC_{50} 1665 ppm for *Microtus ochrogaster*). However, this study is not reported in enough detail to establish a RAL in terms of a dose. Therefore, as for birds, reliable confirmatory information would be required to set an endpoint for risk assessment based on dietary exposure.
Indirect mortality	Birds and mammals	The toxicological studies for birds and mammals do not account for indirect mortality, e.g. starvation and/or dehydration due to impaired foraging performance following sub-lethal exposure to paraquat. Paraquat exposure has been observed to result in reduced food consumption and can damage the digestive tract. The prevalence of any such effects under real world conditions is unknown. This source of uncertainty should be acknowledged in a weight-of-evidence argument.
Contact exposure	Birds and mammals	Paraquat can have toxicological effects due to contact exposure, being both an irritant and potentially causing mortality depending on the specific site of exposure. This would primarily be expected to be of significance to organisms that remain in the treated area during spraying or that enter shortly after spraying before spray deposits have dried. Contact exposure is not considered within the quantitative risk assessment but should be acknowledged as source of uncertainty within a weight-of-evidence argument.

<table>
<tr><th>Source of uncertainty</th><th>Relevant taxa</th><th>Discussion</th></tr>
<tr><td>Avoidance</td><td>Birds</td><td>Specific examples of food avoidance have not been identified for birds. Food avoidance is plausible given the properties of paraquat, the information available for mammals (see below) and observations from the long-term exposure studies[67]. However, reliable quantifiable estimates of the impact of food avoidance cannot be established.</td></tr>
<tr><td></td><td>Mammals</td><td>Experimental data (Linder & Richmond, 1990) indicate that M. ochrogaster (prairie voles) exhibit avoidance of paraquat treated food. Starvation, food type, food availability, energy expenditure, paraquat concentration on dietary food items and variations in inter-species sensitivity may alter the impact of any avoidance behaviour under field conditions.

The experimental data imply the potential for statistically significant differences in food choice, between treated and untreated food, at concentrations as low as 107 ppm. The risk assessment applies a 90^{th} percentile RUD of 102.3 mg/kg for grass food items. Therefore, at application rates of approximately ≥1.0 kg/ha, assuming no interception, the concentration in vegetation would potentially be sufficient to elicit statistically significant differences in food avoidance – at lower application rates or for other food items (with a lower RUD) the same observation would not necessarily apply.</td></tr>
<tr><td>Dehusking</td><td>Birds and mammals</td><td>Dehusking behaviour has been cited as a mechanism that can reduce exposure for seed eating animals. The study Brühl et al. (2011) and the northern zone guidance (Northern Zone 2020) have been cited to support this argument. These publications look at dehusking amongst wood mice (Apodemus sylvaticus) presented with treated and dyed seeds. The observed exposure reductions are summarised below:

<table>
<tr><th></th><th colspan="2">Fungicide treated seeds</th><th colspan="4">Pigmented seeds</th></tr>
<tr><th></th><th>Wheat</th><th>Barley</th><th>Wheat</th><th>Barley</th><th>Maize</th><th>Sunflower</th></tr>
<tr><td>Mean exposure reduction (%)</td><td>61.4</td><td>79.5</td><td>58.0</td><td>84.0</td><td>59.0</td><td>98.8</td></tr>
<tr><td>Dehusking factor</td><td>0.39</td><td>0.21</td><td>0.42</td><td>0.16</td><td>0.41</td><td>0.01</td></tr>
<tr><td>10^{th} percentile exposure reduction (%)</td><td>40.9</td><td>69.3</td><td>38.2</td><td>71.2</td><td>41.1</td><td>96.0</td></tr>
<tr><td>Dehusking factor</td><td>0.59</td><td>0.31</td><td>0.62</td><td>0.29</td><td>0.59</td><td>0.04</td></tr>
</table>

It is noted that whilst dehusking can occur in mammals (e.g. rodents) and birds (mainly smaller birds) the behaviour differs between species and as indicated above between seed types. The EFSA (2009) guidance recommends that dehusking studies are conducted with a defined focal species and ideally with the relevant seed type and product, and that it should also be demonstrated that dehusking occurs under field conditions. Focal-species specific data is not available. However, the available information indicates that for Australian species that do dehusk seeds exposure reductions could be substantial depending on the specific seeds consumed.</td></tr>
</table>

[67] *A. platyrhynchos* exhibited inconsistent (weeks 2, 12, 14 and 16) and slight (≤20%), but statistically significant, reductions in food consumption compared to the control at 100 ppm of paraquat ions in the feed, the maximum tested concentration, in a long-term exposure study (Fink et al. 1982).

Source of uncertainty	Relevant taxa	Discussion
Herbicidal mode of action	Birds and mammals	The herbicidal mode of action of paraquat may affect exposure in ways that are not quantitatively accounted for in the risk assessment: (1) The damage to treated foliage may affect its attractiveness to consumer organisms. This may limit the likelihood of exposure, particularly given the rapid action of paraquat. This effect has not been experimentally demonstrated. However, beyond the initial few hours after application it can reasonably be expected that this will occur to some degree. Any effect will vary between consumer species, between treated plant species and depending on the availability of alternate food sources. This is only relevant to foliar dietary food items. (2) Depending on the degree of defoliation and the specific scenario in question (crop, application timing, etc.), the herbicidal action may alter the vegetation structure. This can influence the identity of species that will forage in the treated area and/or change the behaviour of any foraging species.
Spot spraying	Birds and mammals	Spot spraying, including optical spot spraying, has been accounted for quantitatively by proportionately adjusting the application rate relative to the estimated fraction of the cropped area that is treated (i.e. if 40% of the cropped area is treated the application rate is adjusted to 40% of the full rate). This assumes no bias in foraging within the treated area by a consumer and that there are alternate food sources in non-treated locations. This does not necessarily directly replicate the actual exposure of an organism which will relate to the foraging behaviour of the consumer organism, the availability of food items and the treatment application in relation to those food items. Nor does it account for spray drift within the treated area. This approach may under-estimate the actual exposure for some groups of organisms, e.g. for herbivorous organisms if all potential food items are treated there will be no reduction in exposure even though the treatment is only applied to a fraction of the cropped area.
Focal species	Birds and mammals	Unless specific information has been submitted that allows consideration of focal species, for a particular use situation, the current assessment is based on generic focal species. This is not reason to reject or modify the conclusions of the risk assessment. Where the risk is unresolved it is incumbent on applicants/ holders to provide additional information to refine the risk assessment; this may include identifying focal species and proposing relevant refinements for those species. However, the uncertainty inherent to an assessment based on generic focal species is acknowledged.
Wildlife monitoring data	Birds and mammals	Several submissions during consultation have referenced wildlife monitoring data or anecdotal observations implying a lack of population level effects on terrestrial vertebrates. Wildlife monitoring data is inherently unreliable. Anecdotal reports/claims of no or limited effects of paraquat use on terrestrial vertebrates are similarly unreliable, but with additional limitations. Whilst this line of argument is noted it does not provide a scientifically justifiable basis on which to adjust the conclusions of the risk assessment, and has not been considered further.

Source of uncertainty	Relevant taxa	Discussion
Population effects	Birds and mammals	As described in the current APVMA guidance[68], the aim of the assessment is to protect populations of terrestrial vertebrate species not individual animals, with respect to both acute and chronic exposure. The population of relevance is the local population in the immediate vicinity of the treated area; the assessment does not consider effects at a landscape or pan-Australian level. Whilst protecting populations is the intended aim, the current quantitative risk assessment does not directly evaluate the effect on a population – estimates of individual exposure are used to establish if there is an expectation that risks to individuals may occur and hence exclude situations where there is no risk at the population level. Population level assessment requires additional consideration/analysis, which it is the applicant/holder's responsibility to provide. Field study data or population modelling could be used to consider population level impacts of paraquat use on relevant organisms. This type of information is not currently available. Therefore, it is only possible to consider the impact on populations subjectively.

Bare soil crop group – General weed control in fallow (including minimal/full disturbance, and optical spot spraying), hops, market gardens, nurseries, row crops, potatoes (pre/early emergence), rice (pre/post sowing) and vegetables

Mammals – There are unresolved acute risks for small omnivorous mammals (at rates >427 g ac/ha, or 2 × 288 g ac/ha) (Table 77). For use rates up to 675 g ac/ha the RQ is ≤1.6, at 1505 g ac/ha the RQ is 3.5.

During the commenting period it was noted that small mammals are not expected to routinely use areas with limited ground cover. European wood mice (*Apodemus sylvaticus*), which can establish home ranges within agricultural landscapes, have been observed to have low PT values (90th percentile PT 0.37) in newly drilled cereals fields; considered equivalent to a bare soil situation. PT values are not used in acute assessments (PT = 1.0). However, it is noted that the available information implies that small omnivorous rodents would not routinely use sites with limited ground cover. Specific information related to Australian species has not been cited, though there is reason to expect that Australian rodents would also exhibit reduced habitat use in situations assessed as bare soil, i.e. as a response to the loss of ground cover and increased risk of predation. Similarly, whilst data are lacking for Australian species it is reasonable to expect that at least some species would engage in dehusking behaviour which can substantially reduce exposure from seeds in the diet (Table 79).

The available data are not suitable to quantitatively establish an acceptable risk, and if animals were to forage in these situations some mortality cannot be excluded. But, the aim of the assessment is to avoid population level effects, and for scenarios with limited ground cover it is reasonable to expect that there would be reduced use of these situations by small omnivorous rodents. For uses with relatively small exceedances of the RQ (i.e. rates up to 675 g ac/ha with RQ values ≤1.6) an acceptable risk is concluded on the weight-of-evidence.

Birds – There are unresolved acute risks for small granivorous (at rates >231 g ac/ha or 2 × 144 g ac/ha), small omnivorous (at rates >328 g ac/ha or 2 × 221 g ac/ha) and small insectivorous birds (at rates >523 g ac/ha or 2 × 402 g ac/ha) (Table 78). Few refinements have been proposed and/or are acceptable for birds. Consequently, the risk assessment is largely unchanged from the default Tier-1 assessment. Without confirmatory data a refined RAL, to account for any difference between dietary and oral exposure, cannot currently be established. For birds,

[68] https://www.apvma.gov.au/registrations-and-permits/data-guidelines/risk-assessment-manuals/environment/appendix-a

information that can be used to define focal species or other lines of evidence specific to bare soil scenarios has not been submitted. Therefore, only the generic weight-of-evidence arguments (Table 79) can be considered further. Currently the available information is not sufficient to resolve the risk for birds, and an acceptable risk cannot be established for application rates >231 g ac/ha.

Cotton crop group – Pre-harvest desiccation in cotton

Mammals – Acceptable risks can be concluded based on the refined risk assessment (Table 77), no further consideration is required.

Birds – Acceptable risks were concluded based on the default Tier-1 risk assessment (Table 76), no further consideration is required.

Grassland crop group – General weed control in pasture (includes hay freezing, spray topping to reduce seed set, prevention of ryegrass toxicity, perennial grass seed crops and kikuyu/paspalum pasture)

Mammals – There are unresolved acute risks for small herbivorous (at rates >54 g ac/ha), large herbivorous (at rates >229 g ac/ha), small omnivorous (at rates >424 g ac/ha) and small insectivorous mammals (at rates >1130 g ac/ha) (Table 77). There are unresolved chronic risks for small herbivorous (at rates >242 g ac/ha) and large herbivorous mammals (at rates >1017 g ac/ha).

The chronic risk to small herbivorous and large herbivorous mammals is concluded to be acceptable, despite the results of the quantitative assessment. It is expected that damage to, or elimination of, foliage will remove sources of plant material for repeated exposure, and regrowth of the pasture will dilute any residual residues on foliar food items. Therefore, the estimated residues in the diet cannot be considered reliable and are expected to overestimate the actual chronic exposure.

The acute risk to small herbivores, large herbivores and small omnivores cannot be excluded on the same basis, as the acute assessment relates to short term exposure. No relevant weight-of-evidence arguments have been provided during consultation that are specific to use in grassland situations. There are weight-of-evidence arguments included in Table 79 that would affect the risk to small herbivorous mammals, large herbivorous mammals and small omnivorous mammals. However, without additional argument they are not considered sufficient in isolation to resolve the risk for all the current use rates (as there are RQ values up to 21).

Birds – There are unresolved risks for small granivorous (at rates >231 g ac/ha), large herbivorous (at rates >187 g ac/ha) and small insectivorous birds (at rates >213 g ac/ha) (Table 78). There are unresolved chronic risks for small granivorous (at rates >894 g ac/ha) and large herbivorous birds (at rates >629 g ac/ha). As stated in relation to the bare soil crop group, the risk assessment is largely unchanged, and generic weight-of-evidence arguments (Table 79) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 78, and an acceptable risk cannot be established for application rates >187 g ac/ha.

Grassland crop group – General weed control in industrial vegetation management, public service areas and rights of way

Mammals – There are unresolved acute risks for small herbivorous (at rates >54 g ac/ha), large herbivorous (at rates >229 g ac/ha), small omnivorous (at rates >424 g ac/ha) and small insectivorous mammals (at rates >1130 g ac/ha) (Table 77). There are unresolved chronic risks for small herbivorous (at rates >242 g ac/ha) and large herbivorous mammals (at rates >1017 g ac/ha).

The chronic risk to small herbivorous and large herbivorous mammals is concluded to be acceptable, despite the results of the quantitative assessment. The rationale is the same as for uses on pasture as discussed previously. The acute risk to small herbivores, large herbivores and small omnivores cannot be excluded on the same basis, as the acute assessment relates to short term exposure.

It has been argued during the public comment period that the treatment rate should be modelled assuming only 10% of the area is treated. The appropriateness of this argument depends on both the size of the treated area and the surrounding land use, particularly for mammals which are less mobile than birds. In situations where there is limited alternate vegetation in the land use surrounding the treated area the presence of herbivorous mammals is not expected, due to the lack of food items, and the risk assessment for omnivorous mammals can be considered sufficient to address relevant species – even more modest reductions in the treated area (i.e. ~35% of the area is treated) would be sufficient to resolve the risk for omnivorous mammals. In other cases there will be alternate foraging sites and given the rapid herbicidal action of paraquat significant population level effects are not expected as animals will be able to shift feeding sites. Therefore, the risk is concluded to be acceptable based on the weight-of-evidence at up to the maximum rate proposed for this use type, 1140 g ac/ha.

Birds – There are unresolved risks for small granivorous (at rates >231 g ac/ha), large herbivorous (at rates >187 g ac/ha) and small insectivorous birds (at rates >213 g ac/ha) (Table 78). There are unresolved chronic risks for small granivorous (at rates >894 g ac/ha) and large herbivorous birds (at rates >629 g ac/ha).

For birds a similar situation applies as for mammals, see discussion above, regarding refinement of the treated area and the surrounding land use, noting that birds will typically be more mobile and better able to access alternate foraging sites. When sites with limited alternate foraging options are treated, organisms are not expected to routinely obtain significant fractions of their diet from the treated area. Where there are other local foraging sites organisms will experience reduced exposure due to the small scale of the treatment application. The risk is concluded to be acceptable based on the weight of evidence at up to the maximum rate proposed for this use type, 1140 g ac/ha.

Legume forage crop group – General weed control in lucerne (ungrazed before application)

Mammals – There are unresolved risks for small herbivorous mammals (at rates >545 g ac/ha) (Table 77). The RQ is marginally exceeded (RQ 1.1) at the upper application rates 595 and 600 g ac/ha, acceptable risks are indicated for lower rates.

For lucerne, submissions during consultation have noted that the majority of lucerne production (83-85%) is geographically restricted to the south-east of southern Australia, the distribution of the remaining 15% has not been established. Additionally, threatened species of birds and mammals have been cited for this region of Australia. Current product labels are not restricted to southern Australia and the assessment must address the full on-label use. The information related to threatened species cannot be used to establish focal species in the crop, even for southern Australia, and the risk assessment is not restricted to effects on threatened species. Therefore, these lines of argument are not a suitable basis on which to refine the risk assessment.

However, only small herbivorous mammals are of concern and there is only a marginal exceedance of the RQ. It can be expected that the herbicidal mode of action (Table 79) will limit exposure of this group of organisms and the intent of the assessment is to prevent population level effects. Therefore, based on the weight-of-evidence it is concluded that the risk for this set of uses can be considered acceptable even at the maximum application rates.

Birds – There are unresolved risks for small insectivorous birds (at rates >226 g ac/ha) (Table 78). As stated in relation to the bare soil crop group the risk assessment is largely unchanged, and generic weight-of-evidence arguments (Table 79) are not considered sufficient to resolve the risk. The arguments made during consultation specifically in relation to lucerne (see discussion of mammals above) are not suitable to resolve the risk assessment, either quantitatively or qualitatively. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 78, and an acceptable risk cannot be established for application rates >226 g ac/ha.

Legume forage crop group – General weed control in peanuts (BBCH 10-19) and lucerne (grazed before application)

Mammals – Acceptable risks were concluded based on the default Tier-1 risk assessment (Table 75), no further consideration is required.

Birds – There are unresolved risks for small granivorous (at rates >231 g ac/ha), small omnivorous (at rates >238 g ac/ha) and small insectivorous birds (at rates >213 g ac/ha) (Table 78). As stated in relation to the bare soil crop group the risk assessment is largely unchanged, and generic weight-of-evidence arguments (Table 79) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 78, and an acceptable risk cannot be established for application rates >213 g ac/ha.

Maize crop group – General weed control in sugarcane (over the top spray and inter-row spray)

Mammals – There are unresolved acute risks for small herbivorous (at rates >54 g ac/ha)[69], and small omnivorous mammals (at rates >355 g ac/ha) (Table 77). There are unresolved chronic risks for small herbivorous mammals (at rates >242 g ac/ha). The maximum use rate for sugarcane is 400 g ac/ha.

The chronic risk to small herbivorous and large herbivorous mammals is concluded to be acceptable, despite the results of the quantitative assessment. The rationale is the same as for uses on pasture as discussed previously. The acute risk to small herbivores and small omnivores cannot be excluded on the same basis, as the acute assessment relates to short term exposure.

References were cited during consultation that relate to rodent species in sugarcane situations (Wilson & Whisson 1993, Fuller & Dyer 2008). Additional information related to rodents in sugarcane can be found in Dyer (2007). Whilst not intended as studies to define focal species there is relevant information in Wilson & Whission (1993) and Dyer (2007) regarding the rodent species that frequent sugarcane fields. Given the distribution of sugarcane production the sampled locations in Queensland are expected to provide reasonable geographic coverage to consider the rodent species that are likely to frequent sugarcane fields.

[69] For the over-the-top spray use an updated interception factor (0.25, based on maize as reported in EFSA 2020) could be considered, as the risk assessment assumes the diet constitutes non-crop foliage. For simplicity and given the weight-of-evidence argument (see the following text) this has not been included in the quantitative risk assessment at this time.

Rattus sordidus and *Melomys burtoni* were the main species observed, comprising up to 90 or 38% of rodents captured, respectively. These are both considered pest species in sugarcane, though in other situations this would not be the case. Regardless of their status in sugarcane, based on the information available there is reason to expect that they are not exposed to the extent predicted by the Tier 1 risk assessment. The prevalence at early growth stages is relatively low for both *R. sordidus* and *M. burtoni*, the implication being that individuals move into the crop from the surrounding area. Therefore, only a fraction of the population is expected to frequent sugarcane fields at early growth stages, particularly when over-the-top spraying would occur. The studies that consider dietary composition of *R. sordidus* (Wilson & Whisson 1993) and *M. burtoni* (Dyer 2007, Fuller & Dyer 2008) were not designed specifically for regulatory purposes but do provide useful insights. The proportion of *R. sordidus* individuals with >50% sugarcane, by volume, in their stomach contents was 0.35-0.69 for individuals captured in crop or crop margin. The mean stomach contents of *M. burtoni*, caught in-crop at growth stages 4 and 5, was ~60% seeds, ~20-40% sugarcane and 6-13% other vegetation. Sugarcane is not treated when application is by inter-row spraying, and no paraquat residues can be assumed for sugarcane in the diet – though the actual fraction may vary depending on the timing of any inter-row spraying. The data also implies that exposure of *M. burtoni* will also be reduced by the seed content of their diet. Given the weight-of-evidence and that these are pest species[70] the risk to these species can be assumed to be acceptable.

Other native rodents[71] captured were *Melomys cervinipes*, *Rattus fuscipes*, *Uromys caudimaculatus*, and *Hydromys chrysogaster*. None were captured frequently, though precise numbers are not necessarily available, nor is any comparison to the size of the local population.

- *H. chrysogaster* is carnivorous/piscivorous. Therefore, it is not relevant to this assessment, and the risk is acceptable.
- *U. caudimaculatus* is understood to be omnivorous, though measured data for the diet in a sugarcane situation are not available. The limited data available do not indicate that foliage constitutes a large fraction of the diet (Watts 1977), which would reduce the expected exposure compared to the default assumptions of the risk assessment for omnivorous/herbivorous species. The species is relatively large, with median body weight estimated at 650 g. The species habitat preferences indicate it is not expected to routinely use sugarcane fields. Given these observations the risk is expected to be acceptable, even without considering other weight-of-evidence factors.
- *R. fuscipes* is expected to be omnivorous though foliage can constitute a significant portion of the diet (Cheal 1987, Carron et al. 1990, Watts 1977, Watts & Braithwaite 1978). Specific data related to sugarcane situations are not available. Based on the available information a diet including 50% foliage is considered a reasonably conservative estimate. There are some observations of foliage/stems reaching about 75% of the diet. Assuming a mean body weight of 125 g and a diet of 50% grass[72], 25% seeds and 25% arthropods the RQ would be 1.0 at an application rate of 400 g ac/ha; if the foliar component of the diet were 75% grass the RQ would be 1.9. Treated foliage is only expected to be fully palatable for a short period after treatment (Table 79)

[70] Implying stable local populations despite current management practices.

[71] *Rattus rattus* and *Mus musculus* were also captured.

[72] Conservative option used given the limitations of the available data, as opposed to non-grass weeds typically assumed for omnivorous mammals.

limiting the potential exposure. On balance, for what is a common rodent species in Australia and one that does not appear to routinely use sugarcane, the risk is concluded to be acceptable.

- *M. cervinipes* including a substantial foliar component of the diet cannot be excluded. The available observations of *M. cervinipes* in sugarcane (Wilson & Whisson 1993, Dyer 2007) indicate that the number of individuals in sugarcane is consistently low. Slightly higher abundance is observed later in the season after correcting for sampling effort. How substantial a fraction of the local population this represents is unknown. The species is unlikely to be present in sugarcane early in the crop's growth cycle when over-the-top spraying would occur. The habitat preferences of *M. cervinipes* imply it is not expected to occur frequently in sugarcane situations. Also it is understood that *M. cervinipes* is scansorial which would indicate that foraging on the ground is limited, therefore limiting exposure to residues of paraquat from ground-directed applications. There is uncertainty given the current information, but the available information implies that population level effects are not expected.

Whilst the data are limited for several species, the risk is expected to be acceptable for the species observed to occur in sugarcane. Therefore, the risk from exposure to paraquat can be considered acceptable at up to the current maximum on-label rate (400 g ac/ha).

Birds – There are unresolved risks for medium herbivorous/granivorous (at rates >103 g ac/ha for interrow spraying or >137 g ac/ha for over-the-top spraying), small omnivorous (at rates >238 g ac/ha for interrow spraying or >315 g ac/ha for over-the-top spraying) and small insectivorous birds (at rates >213 g ac/ha for interrow spraying or >302 g ac/ha for over-the-top spraying) (Table 78). As stated in relation to the bare soil crop group the risk assessment is largely unchanged, and generic weight-of-evidence arguments (Table 79) are not considered sufficient to resolve the risk. For the over-the-top spray situation, the risk to all generic focal species would need to be resolved. For the inter-row spray use where paraquat application is directed away from the sugarcane, small omnivorous and small insectivorous birds would only be exposed if they forage on the ground. Therefore, clearer information regarding the timing of this use would be needed to establish the relevance of these generic focal species. For medium herbivorous/granivorous birds the application method is not a mitigating factor, as ground foraging species are assumed to be present in the absence of information to determine relevant focal species. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 78, and an acceptable risk cannot be established for application rates >103 g ac/ha for interrow spraying or >137 g ac/ha for over-the-top spraying.

During the public comment period it was proposed to remove the crop foliage component included in the diet of the small omnivorous bird, when application is by inter-row spraying. This may be justifiable depending on the species present in the crop, assuming there is no substitution for other foliage. However, given the need to resolve the risk for other generic focal species this has not been considered further at this time.

Orchard crop group – General weed control in bananas, dubosia, forests, orchards, plantations and tea tree

Mammals – There are unresolved risks for small herbivorous (at rates >54 g ac/ha or 2 × 39 g ac/ha), large herbivorous (at rates >275 g ac/ha or 2 × 196 g ac/ha) and small omnivorous mammals (at rates >521 g ac/ha or 2 × 398 g ac/ha) (Table 77). There are unresolved chronic risks for small herbivorous mammals (at rates >242 g ac/ha or 2 × 173 g ac/ha).

The chronic risk to small herbivorous and large herbivorous mammals is concluded to be acceptable, despite the results of the quantitative assessment. The rationale is the same as for uses on pasture as discussed previously. The acute risk to small herbivores and small omnivores cannot be excluded on the same basis, as the acute assessment relates to short term exposure.

No relevant weight-of-evidence arguments have been provided during the commenting period that are specific to use in orchards. There are weight-of-evidence arguments included in Table 79 that would affect the risk to small herbivorous mammals, large herbivorous mammals and small omnivorous mammals. However, without additional argument they are not considered sufficient in isolation to resolve the risk for all the current use rates (as there are RQ values up to 21).

Birds – There are unresolved risks for small granivorous (at rates >377 g ac/ha or 2 × 270 g ac/ha) and small insectivorous/worm-feeding birds (at rates >770 g ac/ha) (Table 78). As stated in relation to the bare soil crop group the risk assessment is largely unchanged, and generic weight-of-evidence arguments (Table 79) are not considered sufficient to resolve the risk. No specific argument has been provided regarding insectivorous birds in orchard situations. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 78, and an acceptable risk cannot be established for application rates >377 g ac/ha (or 2 × 270 g ac/ha).

Potato crop group – General weed control in potatoes (pre-harvest)

Mammals – There are unresolved risks for small herbivorous mammals (at rates >363 g ac/ha) (Table 77).

It is noted that comments received have argued that potato cropping situations are unlikely to provide 100% of an animal's food. No data has been submitted to establish which species, if any, occur in potato cropping situations, nor has any supporting information been provided that can be used to quantitatively or qualitatively address this assertion. It should be noted that the unresolved risk is only the acute risk to small herbivorous mammals. At Tier-1 the assumption is that 100% of the diet is obtained from the treated area for a single day – the modelled diet consist of weeds in the treated area and interception by the crop has been accounted for. At present there is insufficient information to assume that a small mammal would be unable to fulfill its dietary requirements for a single day.

There are weight-of-evidence arguments included in Table 79 that would affect the risk to small herbivorous mammals. However, without additional argument they are not considered sufficient in isolation to resolve the risk for all the current use rates (given that there are RQ values up to 1.9).

Further argument could be submitted to refine the risk assessment, e.g. it may be possible to reconsider the relevance of small herbivorous mammals based on the distribution of potato growing regions in Australia. At present such information has not been provided and the conclusion of the Tier-1 risk assessment has not been changed, i.e. the risk is unacceptable at rates >363 g ac/ha for pre-harvest use in potatoes.

Birds – There are unresolved risks for small insectivorous birds (at rates >226 g ac/ha) (Table 78). As stated in relation to the bare soil crop group the risk assessment is largely unchanged, and generic weight-of-evidence arguments (Table 79) are not considered sufficient to resolve the risk. No specific argument has been provided regarding insectivorous birds in potato situations. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 78, and an acceptable risk cannot be established for application rates >226 g ac/ha.

Pulses crop group – Spray topping in pulses

Mammals – For field beans there is an unresolved risk to small herbivorous mammals (at rates >182 g ac/ha) (Table 77), for other pulses an acceptable risk can be concluded based on the refined risk assessment. Only small herbivorous mammals are of concern and there is only a marginal exceedance of the RQ (1.1) at the maximum proposed treatment rate (200g ac/ha). It can be expected that the herbicidal mode of action (Table 79) will limit exposure of this group of organisms and the intent of the assessment is to prevent population level effects. Therefore, based on the weight-or-evidence it is concluded that the risk for this set of uses can be considered acceptable even at the maximum application rate.

Birds – Acceptable risks were concluded based on the default Tier-1 risk assessment (Table 78), no further consideration is required.

Vineyard crop group – General weed control in vineyards

Mammals – There are unresolved risks for small herbivorous (at rates >54 g ac/ha), large herbivorous (at rates >275 g ac/ha) and small omnivorous mammals (at rates >521 g ac/ha) (Table 77). There are unresolved chronic risks for small herbivorous mammals (at rates >242 g ac/ha).

The chronic risk to small herbivorous and large herbivorous mammals is concluded to be acceptable, despite the results of the quantitative assessment. The rationale is the same as for uses on pasture as discussed previously. The acute risk to small herbivores and small omnivores cannot be excluded on the same basis, as the acute assessment relates to short term exposure.

No relevant weight-of-evidence arguments have been provided during consultation that are specific to use in vineyards. There are weight-of-evidence arguments included in Table 79 that would affect the risk to small herbivorous mammals, large herbivorous mammals and small omnivorous mammals. However, without additional argumentation they are not considered sufficient in isolation to resolve the risk for all the current use rates (given that there are RQ values up to 21).

Birds – There are unresolved risks for small granivorous (at rates >377 g ac/ha) and small insectivorous/worm-feeding birds (at rates >770 g ac/ha) (Table 78). As stated in relation to the bare soil crop group the risk assessment is largely unchanged, and generic weight-of-evidence arguments (Table 79) are not considered sufficient to resolve the risk. No specific argument has been provided regarding insectivorous birds in vineyard situations. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 78, and an acceptable risk cannot be established for application rates >377 g ac/ha.

Conclusions

The environment risk assessment conclusions, based on the risk assessment in the preceding sections, are summarised in Table 80. Note that this summary is only relevant for the risk from paraquat when used alone and does not account for combination toxicity. Also, this summary table does not present a conclusion at the level of each individual application rate on every product label. Application rates below the maximum acceptable rate quoted would be considered acceptable. The full list of recommendations (Appendix A) does account for both these issues.

Table 80: Risk assessment conclusions for terrestrial vertebrates

Category	EFSA 2009 crop group	Situation	Maximum application rate & frequency[73]	Birds		Mammals	
				Risk acceptable [74]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
General weed control	Bare soil	Fallow (optical spot spraying)	From 1× 2250 g ac/ha (675 g ac/ha)	No	231	Yes	675 (WOE)
		Fallow	From 1× 1505 g ac/ha	No	231	No	675 (WOE)
		Market gardens, row crops, vegetables	From 1× 600 g ac/ha	No	231	Yes	675 (WOE)
		Market gardens, row crops, vegetables (shielded inter-row sprayers)	From 1× 600 g ac/ha	No	231	Yes	675 (WOE)
		Hops, rice (pre/post sowing), potatoes (pre/early emergence)	From 1× 400 g ac/ha	No	231	Yes	675 (WOE)
	Grassland	Industrial vegetation management	From 1× 1140 g ac/ha	Yes	1140 (WOE)	Yes	1140 (WOE)
		Pasture (includes hay freezing, spray topping to reduce seed set, prevention of ryegrass toxicity, perennial grass seed crops and	From 1× 600 g ac/ha	No	187	No	54

[73] Values in parentheses are the maximum rates adjusted for the fraction of the field treated (FFT)

[74] For all use rates, an acceptable risk will have been concluded for use rates less than or equal to the maximum acceptable rate. The overall conclusion (Yes/No) only relates to whether all uses can be considered to have passed the risk assessment. The overall conclusion accounts for any fraction of the field treated (FFT) refinements as detailed in Table 74.

Category	EFSA 2009 crop group	Situation	Maximum application rate & frequency[73]	Birds		Mammals	
				Risk acceptable [74]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
		kikuyu/paspalum pasture)					
	Legume forage	Lucerne (ungrazed before spraying)	From 1× 600 g ac/ha	No	226	Yes	600 (WOE)
		Peanuts (BBCH 10-19)	From 1× 250 g ac/ha	No	213	Yes	355
	Maize	Sugarcane (over the top spray)	From 1× 400 g ac/ha	No	137	Yes	400 (WOE)
		Sugarcane (inter-row spray)	From 1× 400 g ac/ha	No	103	Yes	400 (WOE)
	Orchards	Orchards, bananas	From 1× 1120 g ac/ha	No	377	No	54
		Spot spray in orchards, bananas	From 1× 1120 g ac/ha (448 g ac/ha)	No	377	No	54
	Potato	Potatoes (pre-harvest)	From 1× 700 g ac/ha	No	226	No	363
	Pulses	Spray topping in pulses	1× 200 g ac/ha	Yes	1057	Yes	200 (WOE)
	Vineyards	Vineyards	From 1× 1120 g ac/ha	No	377	No	54
		Spot spray in vineyards	From 1× 1120 g ac/ha (448 g ac/ha)	No	377	No	54
Combination products containing diquat	Bare soil	Fallow (minimal disturbance)	From 2× 432 g ac/ha 7d interval	No	231	Yes	675 (WOE)
		Fallow (minimal disturbance)	From 1× 432 g ac/ha	No	231	Yes	675 (WOE)

Category	EFSA 2009 crop group	Situation	Maximum application rate & frequency[73]	Birds		Mammals	
				Risk acceptable [74]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
		Fallow (full disturbance)	From 1× 324 g ac/ha	No	231	Yes	675 (WOE)
		Market gardens, nurseries, potatoes (pre/early emergence), rice (pre-emergence), vegetables	From 1× 432 g ac/ha	No	231	Yes	675 (WOE)
		Spot spray in market gardens, nurseries, potatoes (pre/early emergence)	From 1× 432 g ac/ha (173 g ac/ha)	Yes	231	Yes	675 (WOE)
	Cotton	Cotton desiccant	From 1× 216 g ac/ha	Yes	1295	Yes	218
	Grassland	Pasture	From 1× 432 g ac/ha	No	187	No	54
		Public service areas, rights of way	From 1× 432 g ac/ha	Yes	1140 (WOE)	Yes	1140 (WOE)
		Spot spray in public service areas, rights of way	From 1× 432 g ac/ha (173 g ac/ha)	Yes	1140 (WOE)	Yes	1140 (WOE)
	Legume forage	Lucerne (grazed before spraying)75	From 1× 324 g ac/ha	No	213	Yes	355
	Maize	Sugarcane (over the top spray)	From 1× 270 g ac/ha	No	137	Yes	270 (WOE)
		Sugarcane (inter-row spray)	From 1× 270 g ac/ha	No	103	Yes	270 (WOE)

[75] Where grazing occurs immediately before application for lucerne, the risk assessment only considers up to BBCH 19 to account for the limited crop cover

Category	EFSA 2009 crop group	Situation	Maximum application rate & frequency[73]	Birds		Mammals	
				Risk acceptable[74]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
	Potato	Potatoes (pre-harvest)	1× 432 g ac/ha	No	226	No	363
		Spot spray in potatoes (pre-harvest)	1× 432 g ac/ha (173 g ac/ha)	No	226	Yes	363
	Orchards	Forests, orchards, plantations, bananas, dubosia, tea tree	From 1× 432 g ac/ha	No	377	No	54
		Spot application in orchards, plantations, bananas, dubosia	From 1× 432 g ac/ha (173 g ac/ha)	Yes	377	No	54
		Spot application in avocado, custard apples, lychees, mangos	From 2× 324 g ac/ha 14d interval (179 g ac/ha)	Yes	270	No	39
	Vineyards	Vineyards	From 1× 432 g ac/ha	No	377	No	54
		Spot application in vineyards	From 1× 432 g ac/ha (173 g ac/ha)	Yes	377	No	54
Combination products containing amitrole	Bare soil	Fallow (optical spot spraying)	From 1× 1680 g ac/ha (504 g ac/ha)	No	231	Yes	675 (WOE)
		Fallow	From 1× 600 g ac/ha	No	231	Yes	675 (WOE)
	Grassland	Industrial vegetation management	From 1× 850 g ac/ha	Yes	1140 (WOE)	Yes	1140 (WOE)
		Spot spray in industrial	From 1× 500 g ac/ha (200 g ac/ha)	Yes	1140 (WOE)	Yes	1140 (WOE)

Category	EFSA 2009 crop group	Situation	Maximum application rate & frequency[73]	Birds		Mammals	
				Risk acceptable [74]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
		vegetation management					
		Pasture	From 1× 300 g ac/ha	No	187	No	54
	Orchards	Orchards	From 1× 600 g ac/ha	No	377	No	54
		Spot spray in orchards	1× 500 g ac/ha (200 g ac/ha)	Yes	377	No	54
	Potato	Potatoes (pre-harvest)	1× 525 g ac/ha	No	226	No	363
	Vineyards	Vineyards	From 1× 600 g ac/ha	No	377	No	54
		Spot spray in vineyards	1× 500 g ac/ha (200 g ac/ha)	Yes	377	No	54

WOE = weight-of-evidence, the risk assessment conclusion is based on a weight-of-evidence argument

Appendix D – PBT and POP assessments

The Stockholm Convention provides scientifically based criteria for potential POPs (persistent organic pollutants) and a process that ultimately may lead to elimination of a POP substance globally. POPs are persistent, bioaccumulative, and toxic (PBT) and also have potential for long-range transport.

Persistence criterion

The criteria for persistence in Annex D of the convention are expressed as follows:

1. Evidence that the half-life of the chemical in water is greater than 2 months (60 days), or that its half-life in soil is greater than 6 months (180 days), or that its half-life in sediment is greater than 6 months (180 days); or
2. Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of the Convention.

As paraquat is not considered readily biodegradable, a weight of evidence approach is followed.

- A measured degradation half-life for paraquat in sediment is not available. However, in a water sediment system >90% of the applied paraquat was present in sediment after 100 days (Long et al, 1996). Therefore, it is reasonable to conclude the DT_{50} in sediment is >180 days.
- Paraquat was determined to be stable for 180 days in an aerobic study (Vickers et al, 1989a). Additionally DT_{50} values in excess of a year have been observed in several field dissipation studies (Anderson et al, 1992(a), Anderson et al, 1992(b), Anderson et al, 1992(c), Anderson et al, 1992(d), Dyson & Champman 1995, Dyson et al, 1995(a), Dyson et al, 1995(b), Earl et al, 1989, Hance et al, 1980, Lane & Ngim 2000 and Muller & Roy 1997).

Overall, these results show that the degradation of paraquat in freshwater sediment and soil exceeded the persistence threshold. It can thus be concluded that paraquat meets the persistence criterion.

Bioaccumulation criterion

The criteria for bioaccumulation in Annex D of the Stockholm Convention are given as follows:

1. Evidence that the bioconcentration factor or bioaccumulation factor in aquatic species for the chemical is greater than 5000 or, in the absence of such data, that the log Kow is greater than 5;
2. Evidence that a chemical presents other reasons for concern, such as high bioaccumulation in other species, high toxicity or ecotoxicity; or
3. Monitoring data in biota indicating that the bioaccumulation potential of the chemical is sufficient to justify its consideration within the scope of the Convention.

Paraquat is considered not bioaccumulative based on a log Kow of -4.2 (Platford 1983).

Toxicity criterion

The criteria for toxicity in Annex D of the POPs convention are given as follows:

1. Evidence of adverse effects to human health or to the environment that justifies consideration of the chemical within the scope of this Convention; or
2. Toxicity or ecotoxicity data that indicate the potential for damage to human health or to the environment.

The lowest aquatic long-term effect value is below 10 µg/L (lowest NOEC is 0.64 µg/L, Smyth et al, 1992). Therefore, paraquat is considered to meet the toxicity criterion.

Potential for long-range environmental transport

The criteria for long-range transport in Annex D of the Stockholm convention are given as follows:

1. Measured levels of the chemical in locations distant from the sources of its release that are of potential concern;
2. Monitoring data showing that long-range environmental transport, with the potential for transfer to a receiving environment, (via air, water or migratory species); or
3. Environmental fate properties and/or model results that demonstrate that the chemical has a potential for such transportation, 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 2 days.

The modelled atmospheric half-life of paraquat is <2 days (Hayes 2006); therefore, it is unlikely to travel long distances through the air. There is no other evidence to suggest paraquat is transported long distances in the environment.

Conclusion

Paraquat does not fulfil the PBT criteria (not PBT) and has low potential for long-range transport and does not meet the bioaccumulation criterion. Therefore, paraquat does not meet the criteria for POPs in Annex D of the Stockholm Convention.

Acronyms and abbreviations

Shortened term	Full term
μg	microgram(s)
μL	microlitre(s)
ac	active constituent
acs	active constituents
AE	assimilation efficiency
AERP	Adverse Experience Reporting Program
AF	assessment factor
APVMA	Australian Pesticide and Veterinary Medicines Authority
AR	application rate
BBCH	**B**iologische Bundesanstalt, **B**undessortenamt und **CH**emische Industrie
bw	body weight
CC	Codex Commodity Code
CCPR	Codex Committee on Pesticide Residues
CI	confidence interval
cm	centimetre(s)
d	day(s)
DDD	daily dietary dose
DEE	daily energy expenditure
DEFRA	Department for Environment, Food and Rural Affairs
DM	dry matter
ds	dry soil or sediment
DT_{50}	period required for 50 percent dissipation
dw	dry weight
EC_X	effect concentration to X% of the tested population
EEC	estimated exposure concentration

Shortened term	Full term
EFSA	European Food Safety Authority
ER_X	rate causing X% effect
E_rC_x	effect concentration to X% of the tested population, growth rate
ESI	export slaughter interval
EXP	exponential function
ExpE	exposure estimate
FE	food energy
FFT	fraction of field treated
F_{int}	interception factor
FIR	Food ingestion rate
g	gram(s)
GLP	good laboratory practice
h	hour(s)
ha	hectare(s)
HC_X	hazardous concentration for X% of the species
HR	high residue
HR_X	hazardous rate for X% of the species
HPLC	high-performance liquid chromatography
IPM	integrated pest management
JMPR	Joint FAO/WHO Meeting on Pesticide Residues
K_d or K_f	(Freundlich) adsorption constant
kg	kilogram(s)
K_p	sediment sorption coefficient
L	litre(s)
LC_X	lethal concentration to X% of the tested population
LD_X	lethal dose to X% of the tested population
LOC	level of concern

Shortened term	Full term
LOD	limit of detection
LOQ	limit of quantification
LR_X	lethal rate to X% of the tested population
m	metre(s)
MAF	multiple application factor
max	maximum
MC	moisture content
MDR	model deviation ratio
mg	milligram(s)
mL	millilitre(s)
mm	millimetre(s)
mol	mole(s)
NEDI	National Estimated Daily Intake
NESTI	National Estimated Short Term Intake
NOAEL	No observable adverse effect level
NOEC	no observed effect concentration
NOEL	no observable effect level
nm	nanometre(s)
NZEPA	New Zealand Environmental Protection Agency
OC	organic carbon
OECD	Organization for Economic Co-operation and Development
OSST	optical spot spraying technologies
Pa	pascals
PD	proportion of diet
PEC	predicted environmental concentration
PBT	persistent – bioaccumulative – toxic
PEC	predicted environmental concentration

Shortened term	Full term
PHI	post harvest interval
POP	persistent organic pollutant
Pow	octanol-water partition coefficient
PRD	proposed regulatory decision
PT	proportion of an animal's daily diet obtained in habitat treated with pesticide
RAL	regulatory acceptable level
RTR	review technical report
RUD	residue per unit dose
RQ	risk quotient
SAC-WB	strong adsorption capacity – wheat bioassay
SDRAM	spray drift risk assessment manual
SFO	single first order
SL	soluble concentrate
SSD	species sensitivity distribution
STMR	supervised trial median residue
TK	technical concentrate
T-REX	Terrestrial Residue EXposure model
TWA	time-weighted average
µg	micrograms
USEPA	United States Environmental Protection Agency
UV	ultraviolet
w/w	weight per weight
WOE	Weight of evidence

Glossary

Term	Description
active constituent	The substance that is primarily responsible for the effect produced by a chemical product
adsorption constant	A measure of the tendency of a chemical to bind to soils
acute exposure	Contact between a pesticide and a target occurring over a short time (e.g., less than a day)
acute toxicity	Adverse effects of finite duration occurring within a short time (up to 14 d) after administration of a single dose (or exposure to a given concentration) of a test substance or after multiple doses (exposures), usually within 24 h of a starting point (which may be exposure to the toxicant, or loss of reserve capacity, or developmental change, etc.)
adsorption constant	A measure of the tendency of a chemical to bind to soils.
adverse effect	Change in the morphology, physiology, growth, development, reproduction or life span of an organism, system, or subpopulation that results in impairment of the capacity to compensate for additional stress, or an increase in susceptibility to other influences
agricultural crop	Any terrestrial plant species grown commercially for food, fibre, foliage, fuel or medicinal production, with the exception of plants that are not part of a crop under management at the time of pesticide application (eg blackberries or volunteer grain plants that have escaped from a cropped area and become weeds in another area)
aquatic	Relating to water or sediment, as distinct from land or air
assessment factor	Reductive factor by which an observed or estimated endpoint of a pesticide is divided to arrive at a regulatory acceptable level
bioaccumulation	Progressive increase in the amount of a substance in an organism or part of an organism that occurs because the rate of intake exceeds the organism's ability to remove the substance from the body
bioconcentration	Uptake of a pesticide residue from an environmental matrix, usually through partitioning across body surfaces to a concentration in the organism that is usually higher than in the environmental matrix
bioconcentration factor	Ratio between the concentration of pesticide in an organism or tissue and the concentration in the environmental matrix (usually water) at apparent equilibrium during the uptake phase
bound residue	Residue associated with one or more classes of endogenous macromolecules that cannot be disassociated by extraction or digestion without alteration
cation	Monatomic or polyatomic species having one or more elementary charges of the proton
catchment	Landform that collects precipitation and retains it in an impoundment or drains it through a single outlet
chronic exposure	Continued or intermittent long-term contact between an agent and a target
chronic toxicity	Adverse effects following chronic exposure

Term	Description
concentration	Amount of a material, agent (e.g., pesticide) dissolved or contained in unit quantity in a given medium or system
dissipation	Loss of pesticide residues from an environmental compartment due to degradation and transfer to another environmental compartment
dissociation constant	The ratio of concentration of dissociated ions to the concentration of original acid
dose	Total amount of a pesticide or agent administered to, taken up or absorbed by an organism, system, or (sub-) population
dry weight basis	Pesticide residue concentration reported as if the residue were wholly contained in the dry matter of the sample
effect assessment	Combination of analysis and inference of possible consequences of the exposure to a pesticide based on knowledge of the dose–effect relationship associated with that agent in a specific target organism, system, or (sub-) population
endpoint	Measurable ecological or toxicological characteristic or parameter of the test system that is chosen as the most relevant assessment criterion
environmental fate	Destiny of a pesticide or chemical after release to the environment involving considerations such as transport through air, soil, or water, bioconcentration, degradation, etc.
environmental risk	Probability that an adverse effect on humans an environmental system/receptor will be observed for a given exposure to a pesticide based on the probability of that exposure and the sensitivity of the system/receptor
exposure	Concentration or amount of a particular substance that is taken in by an individual, population or ecosystem in a specific frequency over a certain amount of time
exposure assessment	Evaluation of the exposure of an organism, system, or (sub-) population to a pesticide or agent (and its derivatives)
exposure assessment	Evaluation of the exposure of an organism, system, or (sub-) population to a pesticide or agent (and its derivatives)
formulation	A combination of both active and inactive constituents to form the end use product
Freundlich isotherm	Empirical relationship describing the adsorption of a solute from a liquid or gaseous phase to a solid in which the quantity of material adsorbed per unit mass of adsorbent is expressed as a function of the equilibrium concentration of the sorbate.
good laboratory practice	The formalized process and conditions under which laboratory studies on pesticides are planned, performed, monitored, recorded, reported, and audited. Studies performed under GLP are based on the national regulations of a country and are designed to assure the reliability and integrity of the studies and associated data.
half-life	The time taken for the reactant concentration to fall to one-half its initial value
hazard	Inherent property of a pesticide having the potential to cause adverse effects when an organism, system, or (sub-) population is exposed to that agent or situation

Term	Description
Henry's law constant	A gas law that states the amount of gas absorbed by a given volume of liquid at a given temperature is directly proportional to the partial pressure of that gas in equilibrium with that liquid. As such it provides an indication of the preference of a chemical for air relative to water i.e. its volatility
herbicide	Pesticide used for the control of unwanted plants or weeds
hydrolysis	Chemical decomposition induced by water
indicator species	Species whose presence shows the occurrence of defined environmental conditions
intake	Process by which a pesticide or agent crosses an outer exposure surface of a target without passing an absorption barrier, i.e., through ingestion or inhalation.
integrated pest management	Use of pest and environmental information in conjunction with available pest control technologies to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to persons, property, and the environment
larva	Recently hatched insect, fish, or other organism that has different physical characteristics than those seen in the adult, requiring metamorphosis to reach the adult body structure
leaching	Downward movement of pesticides into a soil profile with soil water.
median effective concentration	Statistically derived concentration of a pesticide in an environmental medium expected to produce a certain effect in 50 % of the test organisms in a given population under defined conditions
median lethal concentration	Statistically derived concentration of a substance in an environmental medium expected to kill 50 % of test organisms in a given population under defined conditions
metabolite	Any intermediate or product resulting from metabolism
mineralisation	Conversion of an element from an organic form to an inorganic form. Mineralisation of pesticides most commonly refers to the microbial degradation to carbon dioxide as a terminal metabolite
mode of action	Biochemical effect that occurs at the lowest dose or concentration or is the earliest among a number of biochemical effects that could, understandably, lead to the death of the pest
no observed effect level	Greatest concentration or amount of a substance, found by experiment or observation, which causes no detectable adverse alteration of morphology, functional capacity, growth, development, or life span of the target organism under defined conditions of exposure
non-selective herbicide	Herbicide that is generally toxic to all plants treated
non-target species	Organisms that are not the intended targets of a particular use of a pesticide
partition coefficient	log Pow is the logarithm (base-10) of the partition coefficient between n-octanol and water
persistence	Residence time of a chemical species (pesticide and/or metabolites) subjected to degradation or physical removal in a soil, crop, animal, or other defined environmental compartment

Term	Description
photolysis	Chemical decomposition induced by light or other radiant energy
regulatory acceptable level	Criterion or standard that is considered safe or without appreciable risk
runoff	Portion of the wet precipitation on the land that ultimately reaches streams and, eventually, the sea
soil incorporation	Application of a pesticide to soil by mixing or injection into the soil body
solubility in water	The mass of a given substance (the solute) that can dissolve in a given volume of water
soluble concentrate	A liquid homogenous preparation to be applied as a true solution of the active constituent after dilution with water
strong adsorption capacity – wheat bioassay	A system of calibration by laboratory bioassay for the capacity of a soil to deactivate paraquat by adsorption. Measured as the soil concentration (mg cation/kg dry soil) at which 50% reduced root growth is observed in wheat seedlings. This is approximately equivalent to the soil concentration which, at equilibrium, results in a soil pore water concentration of 0.01 mg/L.
terrestrial	Relating to land, as distinct from water or air
translocation	Movement of a substance within the test system or organism
vapour pressure	The pressure at which a liquid is in equilibrium with its vapour at a given temperature. It is a measure of the tendency of a material to vaporise. The higher the vapour pressure the greater the potential
volatile	Any substance which evaporates quickly
watercourse	A river, creek or other natural watercourse (whether modified or not) in which water is contained or flows (whether permanently or from time to time); and includes: a dam or reservoir that collects water flowing in a watercourse a lake or 'wetland' through which water flows a channel into which the water of a watercourse has been diverted part of a watercourse an estuary through which water flows.
wetland	An area of land where water covers the soil—all year or just at certain times of the year. They include: swamps, marshes billabongs, lakes, lagoons saltmarshes, mudflats mangroves, coral reefs bogs, fens, and peatlands. A 'wetland' may be natural or artificial and its water may be static or flowing, fresh, brackish or saline.

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