Australian Government

Australian Pesticides and Veterinary Medicines Authority

Diquat

Final Review Technical Report

June 2026

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This publication is available from the APVMA website.

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Preface

The Australian Pesticides and Veterinary Medicines Authority (APVMA) is the independent 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 from its advisory agencies. It has been deliberately presented in a manner that is likely to be informative to the widest possible audience, thereby encouraging public comment.

This document contains a summary of the assessment reports generated in the course of the chemical review of an active ingredient, including the registered product and approved labels. The document provides a summary of the APVMA's assessment, which may include details of:

- the toxicology of both the active constituent and product
- the residues and trade assessment
- occupational exposure aspects
- environmental fate, toxicity, potential exposure and hazard
- efficacy and target crop or animal safety.

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: apvma.gov.au.

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Executive Summary

Key outcomes

- Diquat 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 would in a substantial reduction in the number of situations where diquat may be used, but range of uses remain supported.

Overview

Diquat is a non-selective contact herbicide used across a wide range of agricultural settings. The APVMA has completed a reconsideration of diquat 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.

Diquat, and the related chemical paraquat, 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, diquat was present in 56 registered products, including 21 diquat only products and 35 paraquat plus diquat co-formulations. This report deals with the diquat only products, while the paraquat plus diquat co-formulated products are dealt with in the Paraquat Final Review Technical Report.

The APVMA published proposed regulatory decisions on the reconsideration of diquat, and the related chemical paraquat, 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.

Residues and trade assessments, which consider the findings of the environment, toxicology and worker health and safety assessments, support continued use of diquat in most situations that were also supported by those other risk assessments, with the exception of cotton and sugarcane for pre-harvest desiccation and weed control in specific vegetable row crops. 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 diquat 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

Diquat is a non-selective contact herbicide belonging to the bipyridinium class of compounds which also includes the herbicide paraquat. Diquat and paraquat have been registered for use in Australia since 1964. Both compounds share a similar mode of herbicidal action which involves the inhibition of photosynthesis (specifically photosystem I) thereby generating superoxide, leading to lipid peroxidation and membrane damage. Plants die rapidly after treatment and exposure to light.

Purpose of review

Diquat and the related bipyridinium herbicide paraquat were placed under reconsideration by the APVMA, then the National Registration Authority (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 diquat would:

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

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

- Toxicology
- 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 dietary and trade risk for all commodities on which diquat is used
  - Determination of dietary exposure resulting from the consumption of produce treated with diquat
- Environmental safety, including 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.

Product claims, use patterns and mode of action

Diquat is an active constituent in 58 products registered for use in Australia by the APVMA [1]. These products can be divided into 2 groups based on the presence of paraquat as a second active constituent, as indicated in Table 1. These 2 groups can be further divided based on the concentration of diquat and paraquat.

Table 1: Diquat product groups

Group	Active constituent(s)	Active constituent concentration
1 (21 products)	Diquat	200 g/L diquat
2 (37 products)	Paraquat and diquat	135 g/L paraquat; 115 g/L diquat

Diquat and diquat-paraquat combination products are registered for the control of broadleaf weeds in seed beds before sowing, post-emergence inter-row weed control and pre-harvesting operations of a number of crops. Diquat products often include instructions for use as a tank-mix with paraquat or other herbicides to improve efficacy against particular weed species (e.g. capeweed) or provide residual activity (e.g. diuron used for control of annual grasses and broadleaf weeds in lucerne (*Medicago sativa*)). Diquat is also used to facilitate harvesting operations of a number of crops such as desiccating weeds, accelerating the drying of crops and reducing the moisture content of seeds. Additionally, it is registered for use in aquatic situations for control of various aquatic weeds, particularly invasive species. A detailed list of use patterns considered in this assessment is provided in Appendix A – Summary of assessment outcomes.

This reconsideration has only considered the approved label uses of diquat. Assessment of products containing both paraquat and diquat have been considered in the *Paraquat Review Technical Report*. Current permits for use of diquat are not within the scope of this reconsideration.

[1] Note that 3 products registered after 28 February 2024 are not formally within scope of the registration and will be dealt with through separate regulatory actions.

Diquat is a group 22[2] mode of action bipyridinium herbicide and is most commonly supplied as the dibromide salt. It is a non-selective contact herbicide and desiccant, absorbed by the foliage, with some translocation in the xylem. It accepts electrons from photosystem I (PS-I, electron diversion), resulting in interaction with the photosynthetic process to produce a hydroxyl radical and other reactive oxygen species that destroy unsaturated lipids and chlorophyll. It is inactivated on contact with soil and not taken up by plant roots. Diquat is used to control weeds before planting, before or just after crop emergence, and directed spray between the rows of established crops.

[2] Mode of Action tables maintained by Croplife are available on the CropLife website (accessed May 2024).

2 Chemistry

2.1 Active constituent

Diquat dibromide in its pure form is a colourless to yellow-coloured crystal with an earthy odour. Diquat dibromide 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 375–485 g/kg. It is very soluble in water (718 g/L at 20°C in pH 5.2, pH 7.2 and pH 9.2), with a slight solubility in methanol (25 g/L) and is practically insoluble in acetone, dichloromethane, ethyl acetate, hexane and toluene (< 0.1 g/L). Diquat is stable to hydrolysis under acidic, neutral and alkaline conditions. No significant decrease in concentration was observed at pH 5–7, with <10% loss of diquat at pH 7 after 30 days at 25°C. Diquat shows rapid photodegradation with only 15.8% parent compound remaining 3 days after irradiation following first-order kinetics with an estimated half-life of 31 hours. Further information about the identity and physicochemical properties of diquat are provided in Table 2 and Table 3. There are currently 12 active constituent approvals for diquat dibromide which are listed in Table 4.

Table 2: Nomenclature and structural formula of the active constituent diquat

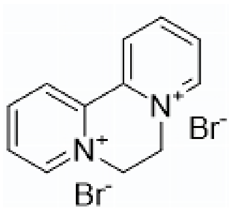
Common name (ISO):	Diquat
IUPAC name:	1,1'-ethylene-2,2'-bipyridyldiylium (diquat) 1,1'-ethylene-2,2'-bipyridyldiylium dibromide (diquat dibromide)
CAS registry number:	2764-72-9 (diquat cation) 85-00-7 (diquat dibromide)
Molecular formula:	C12H12N2 (diquat) C12H12Br2N2 (diquat dibromide)
Molecular weight:	184.2 gmol-1 (diquat cation) 344.1 gmol-1 (diquat dibromide salt)
Structural formula:	

Table 3: Key physicochemical properties of the active constituent diquat dibromide

Appearance	Colourless to yellow crystals solid (pure active ingredient) Dark brown liquid (technical active ingredient)
Melting point	325°C (decomposes before melting)
Relative density	1.61 g/cm
Solubility in water (20°C)	718 g/L at 20°C
Organic solvent solubility (20°C)	Slightly soluble in alcohols and hydroxylic solvents. Practically insoluble in non-polar organic solvents.
Octanol/water partition coefficient (Log Kow)	Log Kow = -4.60 at 20°C
Vapour pressure	<0.01 mPa at 25°C
Henry's law constant (calculated)	$< 5 \times 10^{-9}$ $Pa.m^3mol^{-1}$
Hydrolysis (DT_{50}; 25°C)	DT_{50} at pH 7 in stimulated natural sunlight is 74 days. Hydrolytically stable in the dark condition at pH 4, pH 7 and pH at 50°C for 5 days.
Photolysis (DT_{50})	Aqueous photolysis (DT50) is 1.3 days.

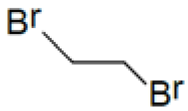
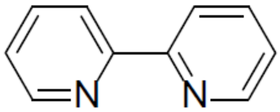
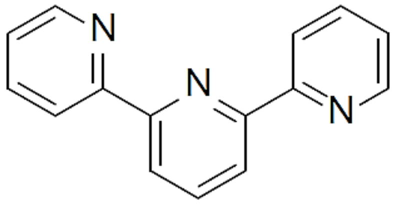
2.1.1 Active constituent standards

The *Agricultural and Veterinary Chemicals Code (Agricultural Active Constituents) Standards 2022* (Agricultural Active Constituents Standards 2022) entry for diquat dibromide specifies a minimum purity of diquat dibromide of 940 g/kg on a dry weight basis, with maximum levels for 2 toxicologically significant impurities of 10 mg/kg for ethylene dibromide and 2.5 g/kg for free 2,2'-bipyridyl (0.25% w/w maximum of the diquat dibromide content).

The Food and Agriculture Organization of The United Nations (FAO) Specifications for Plant Protection Products (FAO Specification for Diquat: FAO, 2008) specification for diquat dibromide technical concentrate (manufacturing concentrate) is 377 g/kg or 467 g/L of diquat dibromide (calculated by multiplying the mass of diquat ion content by 1.87), with maximum levels for 3 toxicologically significant impurities, 10 mg/kg for ethylene dibromide, 0.75 g/kg for free 2,2'-bipyridyl and 1 mg/kg for total terpyridines.

The impurity ethylene dibromide is genotoxic and is a carcinogen while the relevant impurities of 2,2'-bipyridyl and total terpyridines have acute oral toxicity (FAO, 2008).

Figure 1: Structures of toxicologically significant impurities in diquat dibromide

		
Ethylene dibromide	2,2'-bipyridyl	2,2':6', 2"-terpyridines

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
- any other relevant matters.

The manufacturing processes of each source of diquat dibromide were assessed at the time of approval, along with batch analyses of the chemical composition, including the levels of impurities. As these assessments contain commercially confidential information, they will not be discussed further in this report.

Diquat dibromide is manufactured using 2,2'-bipyridyl and 1,2-dibromoethane (ethylene dibromide) as starting materials. As both of these compounds are of toxicological significance, maximum limits have been specified in both the APVMA standard and in the FAO specification for diquat dibromide. Terpyridines, which are also of toxicological significance, can be formed as a byproduct during the manufacture of 2,2'-bipyridyl and can therefore be present in diquat dibromide technical concentrates.

Based on the information considered at the time of approval (particularly the manufacturing process information), other impurities of toxicological significance are not expected to be present in approved sources of diquat dibromide technical concentrate.

A limit for terpyridines is not currently included in the APVMA standard for diquat dibromide. A limit for free 2,2'-bipyridyl is included in the current APVMA standard for diquat dibromide, however it is less conservative than the limit set in the FAO specification (2.5 g/kg compared with 0.75 g/kg in the FAO specification). Due to the toxicological hazard presented by levels of total terpyridines and free 2,2'-bipyridyl exceeding the limit prescribed by the FAO specification, the APVMA is not satisfied that diquat dibromide approvals which do not comply with the FAO specification meet the safety criteria.

Based on the information provided and the assessments conducted at the time of approval, in respect of the chemistry-related matters in the section 5A safety criteria, the APVMA remains satisfied in respect to the manufacturing method for approved diquat dibromide active constituents.

In regard to the analyses of approved diquat dibromide actives and the extent to which they contain impurities, the APVMA is satisfied that the active constituent approvals 44219 and 88714 comply with the FAO specification and therefore meet the safety criteria. The APVMA is not currently satisfied that the remaining diquat dibromide technical concentrate approvals listed in Table 4 meet the safety criteria, as holders of these approvals (56655, 56808, 58221, 58386, 59111, 62650, 64501, 67123, 87160 and 88034) have not provided data to demonstrate that they comply with the FAO specification, including the limit for terpyridines and the more stringent limit for free 2,2'-bipyridyl.

To demonstrate that these approvals satisfy the safety criteria, holders for these active constituents (56655, 56808, 58221, 58386, 59111, 62650, 64501, 67123, 87160 and 88034) would need to provide recent Declarations of Composition and batch analyses demonstrating compliance with the FAO Specification for diquat dibromide.

The APVMA intends to revise the Agricultural Active Constituents Standards 2022 for diquat dibromide technical concentrate to harmonise with the FAO specification, however this will be done as a separate process out of the scope of this reconsideration.

Table 4: Current[3] active constituent approvals for diquat dibromide

Approval number	Approval holder
44219 (manufacturing concentrate)	Syngenta Australia Pty Ltd
56655 (manufacturing concentrate)	Halley International Enterprise (Australia) Pty Ltd
56808 (manufacturing concentrate)	Conquest Crop Protection Pty Ltd
58221 (manufacturing concentrate)	Sinon Australia Pty Limited
58386 (manufacturing concentrate)	ADAMA Australia Pty Limited
59111 (manufacturing concentrate)	Pacific Agriscience Pty Ltd
62650 (manufacturing concentrate)	Agrogill Chemicals Pty Ltd
64501 (manufacturing concentrate)	Sharda Worldwide Exports Pvt Ltd
67123 (manufacturing concentrate)	Titan Ag Pty Ltd
87160 (manufacturing concentrate)	Agrogill Chemicals Pty Ltd
88034 (manufacturing concentrate)	Foisen Scitech Co., Limited

[3] Note that 1 active constituent approved after 28 February 2024 is not formally within scope of the registration and will be dealt with through separate regulatory actions if required.

Approval number	Approval holder
88714 (manufacturing concentrate)	Foisen Scitech Co., Limited

2.2 Formulated products

There are currently 21 registered products containing diquat as the only active constituent. In addition, 35 agricultural chemical products contain both diquat and paraquat as the active constituents. One diquat product and 2 products containing both paraquat and diquat were registered after 28 February 2024 and are not formally considered in the reconsideration. The remaining products are listed in Table 5.

2.2.1 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 (amongst 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.

And 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. Based on the information provided and assessed at the time of registration, the APVMA remains satisfied with respect to the chemistry related aspects of the safety criteria for products containing diquat dibromide 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 the containers for the products met the safety criteria and remains satisfied of that aspect.

All currently registered diquat products are soluble concentrates. The formulation type recorded in the register for all products should be soluble concentrate (SL).

Table 5: Currently registered chemical products containing diquat

Registration number	Product name	Holder	Active constituents	Product group
Products containing diquat as diquat dibromide				
46534	Reglone Non-Residual Herbicide	Syngenta Australia Pty Ltd	Diquat 200 g/L	1
58411	Imtrade Diquat 200 Non-Residual Herbicide	Imtrade Australia Pty Ltd	Diquat 200 g/L	1
58833	Conquest Sanction 200 Non-Residual Herbicide	Conquest Crop Protection Pty Ltd	Diquat 200 g/L	1
59332	Kenso Agcare Diquat 200 Herbicide	Kenso Corporation (M) Sdn. Bhd.	Diquat 200 g/L	1
60297	Dia-Kill 200 Herbicide	Sinon Australia Pty Limited	Diquat 200 g/L	1
63173	Accensi Diquat 200 Non-Residual Herbicide	Australian Agribusiness (Holdings) Pty Ltd	Diquat 200 g/L	1
64177	Titan Diquat 200 Non-Residual Herbicide	Titan Ag Pty Ltd	Diquat 200 g/L	1
64311	Farmalinx Diquat 200 Herbicide	Farmalinx Pty Ltd	Diquat 200 g/L	1
64889	Genfarm Diquat 200 Non-Residual Herbicide	Nutrien Ag Solutions Limited	Diquat 200 g/L	1
65909	Rainbow Diquat 200 Non-Residual Herbicide	Shandong Rainbow International Co Ltd	Diquat 200 g/L	1
66064	KDPC Desiquat Non-Residual Herbicide	KD Plant Care Pty Ltd	Diquat 200 g/L	1
81984	AQ 200 Aquatic Herbicide	Aquatic Site Maintenance Pty Ltd	Diquat 200 g/L	1
82741	Water Treats Aquatic Weed Killer	Clearwater Lakes And Ponds Pty Ltd	Diquat 200 g/L	1
83557	Apparent Diquat 200 Herbicide	Titan Ag Pty Ltd	Diquat 200 g/L	1
84436	4Farmers Diquat 200 Herbicide	4 Farmers Australia Pty Ltd	Diquat 200 g/L	1
88533	Barmac Diquat 200 Herbicide	Australian Agribusiness (Holdings) Pty Ltd	Diquat 200 g/L	1
88796	Foison Diquat 200SL Herbicide	Foison Scitech Co., Limited	Diquat 200 g/L	1

Registration number	Product name	Holder	Active constituents	Product group
89075	Agrevo Diquat 200SL Herbicide	Agrevo Australia Pty Ltd	Diquat 200 g/L	1
90843	Slash 200 SL Herbicide	Asiatic Agricultural Industries Pte Ltd	Diquat 200 g/L	1
92386	KELPIE DIQUAT 200SL Herbicide	SINOCHEM INTERNATIONAL AUSTRALIA PTY. LTD.	Diquat 200 g/L	1
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
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	Australian Agribusiness (Holdings) Pty Ltd	Diquat 115g/L paraquat 135g/L	2

Registration number	Product name	Holder	Active constituents	Product group
63565	Ozcrop Blowout Herbicide	Rainbow Agroscience Australia 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	Blowout 250 SL 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	STRAVIA DIQUAT | PARAQUAT 250 SL HERBICIDE	Stravia Pty Ltd	Diquat 115g/L paraquat 135g/L	2
66788	Agro-Essence Paraquat+Diquat 250 Herbicide	Theyes Management Pty Ltd	Diquat 115g/L paraquat 135g/L	2
67399	Quantum Spray n Sow Herbicide	Quantum Agrosciences Holdings 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
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

Registration number	Product name	Holder	Active constituents	Product group
83923	Accensi Paraquat / Diquat Prime 250 Herbicide	Australian Agribusiness (Holdings) 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	Agmerch Pty Ltd	Diquat 115g/L paraquat 135g/L	2

2.3 Recommendations

The APVMA notes that the limits for impurities of toxicological concern in the FAO specification for diquat dibromide are lower than those in the Active Constituent Standard 2022 for free 2-2'bipyridyl and total terpyridines.

The recommendations of the chemistry assessment are that the APVMA:

- remains satisfied that the diquat dibromide active constituents (manufacturing concentrates) with the approval numbers 44219 and 88714 comply with the FAO Specification for diquat dibromide and continue to meet the safety criteria from a chemistry and manufacture perspective
- 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 do not contain the impurities of toxicological concern identified in the FAO Specification
- could be satisfied that all diquat dibromide active constituent approvals listed in Table 4 meet the safety criteria if the holders of those approvals provide an updated Declaration of Composition and the results of 5 batch analyses to demonstrate that they conform to the FAO Specification for Diquat to the APVMA
- be satisfied that continued registration of products containing diquat dibromide, listed in Table 5, would meet the safety criteria under section 5A of the Agvet Code from a chemistry and manufacture perspective.

3 Toxicology

A large toxicology database is available for diquat and was considered to be of sufficient breadth and quality for human health risk assessment purposes.

The APVMA has completed a review of submissions received in response to the public consultation on the Proposed Regulatory Decision on diquat (consultation period closed 29 October 2024). No new data was submitted that introduced any new toxicological endpoints that would alter the existing health-based guidance values and exposure assessments of diquat.

The following is a summary of the conclusions of the mammalian toxicology and metabolism/toxicokinetics of diquat.

3.1 Evaluation of toxicology

3.1.1 Biochemical aspects

Diquat is rapidly, but poorly absorbed following oral dosing in the rat, with only 4–11% of an oral dose absorbed (Daniel & Gage, 1966). Following absorption, diquat is widely distributed, with highest concentrations in the kidneys; however, it is not extensively metabolised. The highest levels following oral absorption were present in the stomach and intestines reflecting their contents (Johnston et al, 1991). In rats, unchanged diquat was excreted in the faeces, with around 5% of administered dose excreted in the urine (Williams et al, 1991) the majority of the administered dose is excreted in the faeces (up to 80%), with smaller amounts (10–20%) in the urine. Elimination of oral dosing was virtually complete by 168 h after dosing (Johnston et al, 1994 (a,b)), with only 0.02% of the administered dose retained in tissues.

Percutaneous absorption of diquat in male rats resulted in maximum absorption of 3.4% (Brorby et al, 1988). Human skin or isolated epidermis showed lower levels of absorption (Scott et al, 1991a & b) and was also proportional to the amount of diquat applied. The absorption rate for human, rat, rabbit, mouse and guinea pig skins was 0.058, 0.231, 0.333, 0.431 and 0.455 µg diquat cation/cm^2/h, indicating that human skin was the least permeable of tested skin (Scott and Corrigan, 1989).

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

Diquat mediates toxicity to mammals in two principal ways: direct irritation of mucous membranes, and intracellular redox cycling, which generates oxygen radicals that injure or kill cells in which they are formed.

3.1.3 Acute toxicity in animals

The acute oral toxicity of diquat is moderate in rats and mice (lethal dose to 50% of sample (LD_{50}) from 120–231 mg/kg bw; Swan 1960, 1962; Duncan et al, 1985a; McCall and Robinson, 1990a), rabbits and guinea pigs (LD_{50} approximately 100 mg/kg bw; Swan, 1960; Clark and Hurst, 1970). In dogs and monkeys the LD_{50}s were 100–200 mg/kg bw; Swan, 1960; Clark and Hurst, 1970). A range of clinical signs have been observed in laboratory animals following acute oral exposures including pupillary dilatation, difficulty in breathing, weight loss, piloerection, hypothermia, distended abdomen, upward curvature of the spine, staining around the mouth and nose, diarrhoea and incontinence.

In rats, the acute dermal toxicity of diquat is moderate (LD_{50} > 420 mg/kg bw; McCall and Robinson, 1990b); however, there is high dermal toxicity in rabbits (50 mg/kg bw; Duncan et al, 1985b). The acute inhalational toxicity in rats is high (LC_{50} = 121 mg/m3, whole body exposure, 4-h; Bruce et al, 1985). Diquat manufacturing concentrate was a slight skin irritant (Robinson, 1998a) and a slight eye irritant (Levy et al, 1979; Robinson, 1998(b)). While diquat dibromide was a moderate sensitiser (Rattray and Robinson, 1990), a diquat manufacturing concentration was negative for sensitisation (Thompson et al, 1985).

3.1.4 Acute toxicity in humans

Accidents resulting in human exposure to diquat have resulted in severe skin and eye damage, as well as corrosive damage to the mucosa following ingestion. Paralytic ileus can result in accumulation of fluid in the gut, leading to hypovolaemic shock. Nephrotoxicity, ranging from transient proteinuria to renal failure frequently occurs (Jones and Vale, 2000; Vanholder et al, 1981). Treatment with gastric lavage and the administration of activated charcoal, as well as supportive therapy, has been effective. Diquat is poorly absorbed through human skin, at around 0.3% (Feldmann & Maibach 1974).

3.1.5 Repeat dose toxicity

3.1.5.1 Ocular toxicity

Diquat causes cataracts in experimental animals on repeated administration. Although 8–16 weeks of continuous exposure was required in rats and dogs, cataract formation is the most sensitive indicator of medium- and long-term dietary exposure to diquat and is one of the toxicological effects upon which the original NOAEL of 0.2 mg/kg bw/d in rats was based. However, re-evaluation of this study has determined that there is no evidence of progression in rats at 15 ppm (equal to 0.6 mg/kg bw/d; Hodge, 1988; Hodge, 1989(a)), in contrast to effects at higher doses, and this is now considered to be the NOAEL for the study. The LOAELs for cataract formation were 3.6 mg/kg bw/d in rats and 2.5 mg/kg bw/d in dogs (Hopkins, 1990). Several chronic studies revealed time- and dose-dependency in the rate of onset, which was hastened by increasing doses. Interestingly, mice did not develop cataracts in 80-week and 2-year studies at doses up to approximately 50 mg/kg bw/d (Hodge, 1992(a,b)). Early studies demonstrated that diquat cataractogenesis was independent of ambient light and could not be ameliorated by dietary supplementation with ascorbic acid. It has subsequently been suggested that the reductive potential of diquat is involved in cataract formation. Injection of 300 nmol diquat into the eyes of rabbits results in enlargement and vacuolation of the posterior and anterior lens sutures within 1–3 days, separation of lens fibres within 3–4 days and complete opacity of the lens within 4–6 weeks after administration (Bhuyan and Bhuyan, 1994). These observations correlate with increased intra-ocular formation of oxy and hydroxyl radicals and hydrogen peroxide (H_2O_2), produced by the reaction of diquat free radical with O_2. While the mechanisms underlying diquat cataractogenesis in laboratory species would also operate in humans, there has been no evidence that diquat has caused cataracts to develop in humans, even among occupationally exposed persons.

3.1.5.2 Renal toxicity

The kidney is the major route of excretion of diquat and is the organ in which the highest tissue residue levels of the chemical are found. The kidney is therefore vulnerable to cellular injury caused by superoxide anions generated from diquat by redox cycling. In primates and humans, the impairment and loss of renal function following acute poisoning with diquat has been well documented, as has the destruction and shedding of cells lining the renal tubule.

Renal toxicity has also been observed in repeat-dose studies with diquat, affecting mice, rats and dogs. Of these 3 species, the rat appears to be the most sensitive, developing renal impairment at and above 2.9 mg/kg bw/d during the second half of a 2-year study, although without any associated morphological abnormalities (Colley et al, 1985). Rats fed 28 mg/kg bw/d diquat over 4 weeks displayed polyuria whereas those receiving 40 mg diquat/kg bw/d in a subchronic study showed an increased tendency to shed renal tubule cells into the urine (Horner, 1992(a)). At approximately 22 mg/kg bw/d, parental generation rats in a reproduction study had renal tubular dilatation and hypertrophy/hyperplasia of the collecting duct, whereas their offspring manifested a variety of lesions in the renal cortex, nephrons and papillae (Hodge, 1990). Urinary incontinence, renal tubule dilation and tubular hyaline droplet formation occurred at and above 12 mg/kg bw/d in chronically exposed mice (Hodge, 1992(a,b). Renal enlargement, although not functional impairment, was seen in dogs at the termination of a 1-year dietary study in which they had been treated with diquat at 12.5 mg/kg bw/d (Hopkins, 1990).

Taken together, these results suggest that the kidney is able to withstand prolonged dietary exposure to diquat at doses equivalent to 10–20% of the LD_{50}.

3.1.5.3 Gastrointestinal tract toxicity

Consistent with its inflammatory and destructive effects on the gastrointestinal tract (GIT) epithelium subsequent to acute administration, diquat also causes similar lesions after repeated dosing. In developmental studies, stomach and intestinal inflammation and other abnormalities were found in some rabbit dams gavaged at 5 and 10 mg/kg bw/d. Short-term repeat-dose, subchronic and chronic studies in rats and dogs showed that these species are highly sensitive to irritant effects on the mouth, stomach and intestine when treated with diquat by dietary admixture. Indeed, the maximum dose was limited by ulceration and development of other lesions within the oral cavity. Even comparatively low concentrations of diquat in the feed caused macro- and microscopically detectable changes in intestinal morphology. A 1-year study by Hopkins (1990) recorded inflammation and hypertrophy of the intestine in dogs receiving 0.5 mg diquat/kg bw/d or more.

3.1.6 Genotoxicity

Diquat has been assayed for genotoxicity in a wide variety of *in vitro* and *in vivo* test systems. Negative results have been obtained in assays for reverse mutation in bacteria (Callander, 1986 (a,b)), recessive lethal mutation in insects (Benes and Sram, 1969), dominant lethal mutation in mice (Pasi et al ,1974; McGregor, 1974), clastogenic activity in mice (Sheldon et al, 1986) and rats (Anderson et al, 1978), and unscheduled DNA synthesis in rats (Trueman RW, 1987). Although diquat has caused forward mutation and clastogenicity in cultured mammalian cells, these effects were observed only in the presence of marked cytotoxicity, and so are not indicative of genotoxic activity *per se* (Richardson et al, 1986; Wildgoose et al, 1986).

3.1.7 Carcinogenicity

Long-term feeding studies in mice and rats revealed no evidence that diquat was carcinogenic (Colley, 1995; Hodge, 1992(a,b); Harling et al, 1997).

3.1.8 Reproduction studies

Diquat does not cause reproductive toxicity or foetal developmental malformations but is fetotoxic at maternally toxic doses. In adequate multi-generation rat studies, cataracts, oral cavity lesions and impeded food utilisation occurred in parental animals, consistent with effects noted in some repeat-dose and chronic studies (Griffiths et al, 1966; Fletcher et al, 1972; Hodge, 1990). These findings were accompanied by reduced litter size, pup bodyweight and bodyweight gain and functional and morphological evidence of injury to the urinary tract of pups. Cataracts did not occur in pups. The lowest parental NOAEL was 1.4 mg/kg bw/d, while the NOAEL in pups was 7 mg/kg bw/d (Griffiths et al, 1966; Fletcher et al 1972).

3.1.9 Developmental studies

In developmental studies, the most sensitive species appears to be the mouse, in which NOAELs for foeto- and materno-toxicity were not established even at the lowest dose of 1 mg/kg bw/d (Palmer et al, 1978). By contrast, rats are more resistant, showing lowest NOAELs of 4 mg/kg bw/d for materno- and foeto-toxicity (Wickramaratne, 1989 (a, b)). The lowest maternal and foetal NOAELs in rabbits were 1 and 3 mg/kg bw/d, respectively (Hodge, 1989 (b)). In all 3 species, the most consistent toxic signs were depressed maternal body weight gain, foetal viability and foetal growth, and delayed foetal ossification. Ocular injury was never observed in pups or foetuses.

3.1.10 Special studies

3.1.10.1 Neurotoxicity

In both humans and animals, diquat is capable of causing central nervous system (CNS) effects at or near lethal doses. Rats given high doses orally or by injection show pupillary dilation, abolition of the light reflex, muscular twitching and convulsions. Intoxicated persons may display nervousness, disorientation and diminished reflexes. Persistent neurological symptoms have been observed following non-fatal diquat poisoning (Rudez et al. 1999), while grand mal seizures may occur in patients who do not survive. Coma is invariably present in fatal cases. These effects are thought to arise from injury to the brain, in which perivascular haemorrhage, tissue lysis and infarction of the pons are commonly found postmortem (Jones and Vale, 2000).

Modern acute and repeat-dose neurotoxicity studies with diquat in rats have been assessed (Horner, 1992 (a,b)). There were no behavioural signs indicative of CNS impairment and no pathological features consistent with injury to the brain or peripheral nervous system, at even the highest doses.

There is no convincing evidence that diquat induces Parkinson’s disease or any similar condition in humans or animals. Only a small (0.5%) proportion of an intravenous (IV) dose of diquat is taken up into the mouse brain, from which the chemical becomes rapidly depleted. A search of the available literature has not revealed any other reports associating diquat with Parkinson’s disease in humans.

3.1.10.2 Human studies

The toxicity of diquat has been well characterised in humans, in part because of the considerable extent and duration of its use as a herbicide, as well as incidents involving accidental or suicidal ingestion of diquat products.

In general, the symptoms of human exposure to toxicologically significant amounts of diquat are similar to those reported in acute and short-term studies in animals. Due to its irritancy to the skin and mucous membranes, inflammation and bleeding of the nasal mucosa have been observed in people handling crystalline diquat powder under laboratory conditions, and heavy inhalation exposure to diquat spray mist can cause irritation of the upper respiratory tract. Concentrated diquat products have been reported to delay the healing of superficial cuts on the hands of spray operators, and to cause discolouration, growth disturbances and shedding of finger or toenails.

Diquat poisoning is less common than paraquat poisoning, but the misuse of diquat has caused numerous human fatalities and cases requiring hospitalisation. The dark brown to black colour of concentrated diquat solutions has contributed to their being mistaken for soft drinks when decanted from the original container into soft drink bottles. Particularly in Japan and some developing countries, diquat and/or paraquat have been used as an agent of suicide. Since 1987, however, there has been a decline in most countries in the total numbers of suicidal deaths, although the mortality rate among persons who have swallowed diquat or paraquat remains high (Reigart and Roberts 1999). The estimated lowest lethal dose of diquat in humans is 6 g (approximately 85 mg/kg bw); clinical experience suggests that fatality will occur in one third of the cases after an ingested dose of 1–12 g, while intakes of 12 g or more are usually fatal (Jones and Vale, 2000).

Even though intestinal absorption of diquat is relatively slow, uptake into target organs and tissues occurs within 6–18 h. The early symptoms of ingested diquat poisoning arise from irritation to the oral and gastric mucosa. They include burning pain in the mouth, throat, chest and abdomen, intense nausea, vomiting and diarrhoea. Blood may appear in the vomitus or faeces. Intestinal paralysis may occur, with pooling of fluid in the gut. The kidney is both the principal organ of excretion and target organ, and renal injury is a prominent feature in cases of diquat poisoning, especially among patients who die. Proteinuria, haematuria and pyuria (excretion of pus) and elevated blood urea nitrogen (BUN) may be observed, with possible progression to renal failure. Liver injury may also occur, seen as elevated serum ALP, AST, ALT and LDH activity, sometimes accompanied by jaundice. Some patients display signs of CNS toxicity including nervousness, irritability, restlessness, combativeness, disorientation, nonsensical statements and diminished reflexes. Neurological signs sometimes progress to coma, accompanied by tonic-clonic seizures. Brain stem infarction, particularly involving the pons, have been noted consistently in fatal cases. If the patient survives for several hours or days, circulatory function may fail due to dehydration. Hypotension and tachycardia can occur, with shock resulting in death. Toxic cardiomyopathy or a secondary infection such as bronchopneumonia may develop (Reigart and Roberts 1999; Jones and Vale 2000).

There is no antidote, and the single most effective treatment is to prevent absorption of diquat from the GIT by administration of bentonite, Fuller’s earth or activated charcoal. While the use of intestinal lavage has been recommended, its effectiveness is in doubt and it should not be performed later than 1 h post ingestion, due to the risk of inducing bleeding, perforation or scarring in the bowel if it has already suffered irritation, necrotic or other traumatic injury (Reigart and Roberts, 1999; Jones and Vale 2000). Maintenance of adequate urinary output with IV fluids is considered to be essential to correct dehydration and metabolic acidosis, accelerate diquat excretion and reduce the concentration of diquat within the renal tubule. However, IV infusion must cease if renal failure develops, in which case haemodialysis should be performed. Reigart and Roberts (1999) warn that haemodialysis is not effective in clearing diquat from the blood and tissues, probably because the bipyridyl herbicides have a large volume of distribution.

3.2 Health-based guidance values

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; rat)	Decreased food consumption, serum chemistry changes, increased urinary volume and increased kidney weight	NOEL 200 ppm, equal to 17 mg/kg bw/day LOEL 350 ppm, equal to 30 mg/kg bw/day	Colley et al, 1981
	13 week dietary repeat dose, rat (adult)	Reduced weight gain, food consumption and food utilisation. Cataracts developed from week 8 at 500 ppm (40 mg/kg bw/d)	NOAEL 100 ppm (8.9 mg/kg bw/day)	Hodge 1988b and 1989a
	13 week dietary repeat dose, rat (adult)	Ocular lesions and lens opacities evident at 300 ppm	NOAEL of 60ppm (4.7 mg/kg bw/d)	Noakes, 2003
Long term oral exposure	2 year oral (dietary repeat dose; rat (adult)	Cataracts	NOEL – 15 ppm 0.58 mg/kg bw/day LOEL – 75 ppm	Colley et al, 1985
Reproduction and development				
Reproduction	Three-generation reproduction study; rat	Parents: cataracts, decreased bodyweight Offspring: decreased bodyweight	Parental: NOAEL 125 ppm (6.9 mg/kg bw/day Offspring: NOAEL 6.9 mg/kg bw/day	Fletcher et al 1972, Griffiths et al, 1966

The acceptable daily intake (ADI) and acute reference dose (ARfD) for diquat will be retained (shown in Tables 7 and 8).

Table 7: Acceptable daily intake for diquat

Chemical	ADI mg/kg bw/day	NOAEL	Date	Study	Comments
Diquat ion	0.006	0.6	15 July 2019	2-year dietary rat study; a NOAEL of 0.6 mg/kg bw/d was based on lenticular cataract formation at the next higher dose	Acceptable margin of exposure ≥ 100

Table 8: Acute reference dose for diquat

Chemical	ARfD mg/kg bw/day	NOAEL	Date	Study	Comments
Diquat ion	0.8	75	15 July 2019	Acute neurotoxicity rat study: a NOAEL of 75 mg/kg bw was based on clinical signs, inappetence and reduced bodyweight gain at the next higher dose	

3.3 Poisons scheduling

Diquat is currently included in Schedule 7 of the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP) except when included in Schedule 6. Diquat is included in Schedule 6 in preparations containing 20% or less of diquat.

No change to the current poisons scheduling is 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 diquat.

The diquat toxicology component of the Review Technical Report concluded that, provided conditions of registration and label instructions were followed:

- That the active constituents and registration of products containing diquat would not be an undue hazard to the safety of people exposed to it during its handling or people using anything containing its residues when used in accordance with directions for use.
- That the active constituents and registration of products containing diquat would not be likely to have an effect that is harmful to human beings when used in accordance with directions for use.
- The acceptable daily intake (ADI) for diquat should remain at 0.006 mg per kilogram body weight per day based on a no observed adverse effect level of 0.6 mg/kg bw/day in a 2-year rat dietary study, based on lenticular cataract formation 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 diquat should remain at 0.8 mg of diquat per kg body weight based on a no observed adverse effect level of 75 mg per kilogram body weight in a rat acute neurotoxicity study. The ARfD incorporates a 100-fold uncertainty factor to account for inter- and intra-species variation in sensitivity.
- That the scheduling for diquat in the Standard for the Uniform Scheduling of Medicines and Poisons remain unchanged.

4 Worker health and safety

The risks associated with the use of products containing diquat have been assessed in accordance with the APVMA Human Health Risk Assessment Manual, and a summary of the evaluation is presented.

4.1 Worker exposure assessment

This exposure assessment and risk characterisations includes professional workers who mix, load and apply diquat 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 Calculator (US EPA 2020(a)). For exposure associated with re-entry into pesticide treated area, the current assessment has utilised the US EPA Occupational Pesticide Re-entry Exposure Calculator (US EPA 2020(b)).

The following assumptions have been used in the exposure modelling (see Table 9).

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

Parameter	Value
Point of departure for risk assessment (diquat)	0.282 mg/kg bw/day (based on NOAEL of 4.7 mg/kg bw/day and a 6% oral availability)
Acceptable margin of exposure (MOE)	100 [4]
Body weight (adult)	80 kg
Body weight (child)	1 to 2 y: 11 kg 2 to 3 y: 15 kg
Dermal absorption factor (diquat)	3.3%
Dermal absorption factor (paraquat)	0.3%
Inhalation absorption factor (paraquat and diquat)	100%
Small scale agriculture ground boom application	6 ha/day

[4] 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.

Parameter	Value
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
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 diquat 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 diquat, in addition to any personal protective equipment specified on product labels.

4.1.1 Ground-based and aerial application

The outcomes for the exposure risk assessments for the professional use of diquat in agricultural situations using ground-based or aerial application equipment are set out in Table 10. Modelling for ground-based application assumed that all steps in the use of diquat 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 were 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 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). The APVMA then assessed whether the maximum active handling rate was practical based on the expected scale of use (as indicated in Table 10. As the maximum concentration of diquat 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.

Table 10: Risk assessment outcomes for liquid diquat products

Activity	Scale of use assessed	Minimum acceptable Personal [5] Protective Equipment (PPE)	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	Restricted[5]
	Broad scale agriculture (up to 500 ha/day for all crops and 400 ha/d for cotton)	Enclosed cab application Closed 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[5] Maximum acceptable handling rate of 317.7 kg of diquat per individual worker per day
Aerial application	Pilot exposure extrapolated from enclosed cab ground application	Enclosed cab application	Restricted[5] Maximum acceptable handling rate of 543.0 kg of diquat per individual worker per day
Closed mixing and loading for aerial application	Mixing and loading only	Closed 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[5] Maximum acceptable handling rate of 765.1 kg of diquat per individual worker per day
Backpack sprayer (a single operator mixes, loads and applies)	150 L/day	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	No Maximum acceptable handling rate of 0.2 kg of diquat per individual worker per day
Manually pressurised hand wand application (a single operator	150 L/day	Double layer Gloves	Yes Maximum acceptable handling rate of 8.2 kg of diquat per

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

Activity	Scale of use assessed	Minimum acceptable Personal[5] Protective Equipment (PPE)	Use acceptable (Yes/No/Restricted)
mixes, loads and applies)*		PF50 respirator Face shield or goggles when mixing and loading	individual worker per day
Mechanically pressurised hand wand application (a single operator mixes, loads and applies)*	1,000 L/day spot treatment foliar 4,000 L/day Broadcast foliar treatment	Double layer Gloves PF50 respirator Face shield or goggles when mixing and loading	Yes Maximum acceptable handling rate of 2.3 kg diquat per individual worker per day

4.1.2 Re-entry to treated areas

Based on the acute hazards associated with exposure to diquat, treated areas should not be entered until the spray has dried, unless using an enclosed cab or wearing cotton overalls and gloves.

The recommended re-entry periods depend on the application rate and activity, as specified below in Table 11 for diquat products.

Table 11: Re-entry intervals diquat products

Activity	Non-Re-Entry Period (Days)[1]
Scouting (application rate up to 400 g/ha)	0
Scouting (application rate of 401 to ≤ 600 g/ha)	1
Scouting (application rate of 601 to ≤ 800 g/ha)	4
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 ≤ 600 g/ha)	7
Irrigation (hand set) (application rate of 601 to ≤ 800 g/ha)	9
Mechanical cotton harvesting (round modules) application rate of 140 g/ha	0
Mechanical cotton harvesting (round modules) application rate of 141 to ≤ 400 g/ha	7
Mechanical cotton harvesting (round modules) application rate of 401 to ≤ 500 g/ha	9
Mechanical cotton harvesting (round modules) application rate of 501 to ≤ 600 g/ha	11

Activity	Non-Re-Entry Period (Days)[1]
Mechanical cotton harvesting (square modules) application rate of 140 g/ha	4
Mechanical cotton harvesting (square modules) application rate of 141 to ≤ 400 g/ha	14
Mechanical cotton harvesting (square modules) application rate of 401 to ≤ 500 g/ha	16
Mechanical cotton harvesting (square modules) application rate of 501 to ≤ 600 g/ha	18

[1]Day of spraying is Day 0.

4.2 Recommended label changes

4.2.1 Signal headings

Diquat is currently included in Schedule 7 of the Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP) except when included in Schedule 6. Diquat is included in Schedule 6 in preparations containing 20% or less of diquat.

No change to the current signal heading is required.

4.2.2 Restraints

4.2.2.1 General restraints

- DO NOT remove contents except for immediate use.
- DO NOT apply by spraying equipment carried on the back of the users.
- DO NOT use open mixing/loading equipment. Closed mixing and loading must be used.
- DO NOT continue to use if eye irritation or bleeding from the nose occurs.

4.2.2.2 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 boom spray application (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.

4.2.3 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.

4.2.4 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 pressure (manually pressurised) or high pressure (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.

4.2.5 Re-entry statements for diquat 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, irrigation and cotton harvesting activities must comply with the re-entry periods specified in Table 11.

5 Residues and trade

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

5.1 Metabolism

Metabolism studies conducted on plants, laboratory animals and food animals were considered.

Metabolism studies in tomatoes and maize (Slade, 1966), cereals (Leahey et al, 1973; Cavell, 1987; Heath and Leahey, 1989), potatoes (Smith, 1967) and oil seed rape (Leahey and Allard, 1971), as well as an irradiation study in aqueous solutions of glucose (Heath, 1992), demonstrate that diquat undergoes photodegradation on the plant surface rather than extensive metabolism in the plant. In the studies with tomatoes and maize, when the treated plants were maintained in darkness, no breakdown of diquat occurred; however, when they were exposed to sunlight there was very rapid loss of diquat and degradation continued when the plants were dead.

Diquat was the major component and the compound 1,2,3,4-tetrahydro-1-oxopyrido[1,2-a]-5-pyrazinium chloride (TOPPS) the most important single identified photoproduct. The compounds diquat monopyridone and diquat dipyridone were also formed in low levels (≤7.5% TRR). The major proportion of the residue on the treated crops parts consists of a complex mixture of unidentified photodegradation products bound to the natural plant constituents. This was likely to be the result of the photo-initiated generation of diquat free radicals which then react with the natural constituents. The degradation of diquat was dependent on light intensity and there is no evidence of translocation of the photoproducts and only limited translocation of diquat.

Studies conducted on the rat (Leahey, 1974), goat (Hemingway et al, 1973), lactating cow (Leahey et al, 1976; Hemingway et al, 1974) and laying hen (Leahey and Hemingway, 1973; Hughes and Leahey, 1975; French and Leahey, 1988) indicate that diquat is poorly absorbed after oral administration and is excreted largely unchanged, mostly in the faeces, with TOPPS and diquat monopyridone present in low amounts (≤10.5% TOPPS and <4% diquat monpyridone in goat faeces). Highest residues occurred in the liver and kidneys and consisted of low levels of diquat and diquat monopyridone. Traces of degradation products were present in milk and eggs at low levels (0.005 mg/kg), with the majority shown to be incorporated into natural constituents such as protein, fat and lactose.

5.2 Analytical methods and storage stability

5.2.1 Analytical methods

Twenty-seven reports of analytical method and validation studies were submitted. The analytical methods related to plants materials (Fujie, 1987(a); Earl and Boseley, 1989; Hogbin and Thorndycraft, 1992; Anderson, 1994(a,b); Reichert, 1996), animal tissues (Kennedy, 1986(a); Fujie, 1987(b); Earl, 1992(a); Earl, 1993(a); Anderson, 1996(a); Bolton, 1996), milk (Earl, 1992(b), water (Anderson, 1994(a)), oils (Anderson, 1995), soils (Coombe, 1994; Anderson and Boseley, 1995; Weber, 1995; James, 1996; Anderson and Boseley, 1997) and human plasma, serum and urine (Thomas and Woollen, 1994; Thomas 1995(a,b)).

The studies submitted included colorimetric, gas chromatographic and liquid chromatographic methods. One residues study of diquat in rice includes the method for measurement of TOPPS in rice grain and straw, otherwise all other methods submitted determine the parent compound only.

The limits of quantification (LOQs) of these methods ranged from 0.01 to 0.05 mg/kg for plant commodities, except for sunflower seed and rape seed for which the LOQ was up to 0.1 mg/kg and for rape seed cake, for which the LOQ was 0.5 mg/kg. For animal commodities, the LOQs ranged from 0.01 to 0.05 mg/kg for milk and 0.05 mg/kg for all other commodities.

5.2.2 Stability of residues in stored analytical samples

Data were presented of studies conducted on the stability of diquat residues during frozen storage in a wide range of commodities.

One study measured diquat residues in samples of wheat and barley grain stored at both ambient temperature and frozen at –18ºC for a period of 6–8 months (Bullock, 1980). In another study diquat residues were measured periodically in coffee beans and bananas frozen at –18ºC for up to 12 months (Coombe, 1995(a,b)). There was no significant decay measured over the test periods in both studies.

In a longer-term study, samples of carrot, cabbage and wheat grain were fortified with diquat then frozen (Fujie, 1988(a); Anderson, 1996(b)). Carrot and cabbage samples were analysed in triplicate at intervals over a period of 46 months and samples of wheat grain were analysed in triplicate at intervals over a period of 18 months. Diquat residues in all 3 crops were found to be stable under these conditions.

A further study conducted to assess the stability of diquat in samples of clover seed and hay, sorghum grain, soybeans, carrots, lettuce, potatoes, wheat grain and straw, and rice grain and straw which were stored for 6 months at –20ºC (Earl and Muir, 1988; Langridge, 2013). For clover, sorghum and soybeans, field-incurred residues were present, and the stability was measured by re-analysis of replicate samples from the treated crops. For carrots, lettuce, wheat, rice and potatoes, untreated control samples were fortified. Diquat residues were found to be stable in the macerated crop matrices for a minimum of 6 months.

In another study, chaff from wheat harvested 7 days after treatment with C14-diquat and stored frozen for 5–6 years was milled to a homogenous sample. On combustion, the total radioactive residue was measured as 157 mg/kg. This was compared to 168 mg/kg at the time of initial analysis (Bullock, 1980).

5.3 Residue definition

Due to little metabolism of diquat in plants and animals, diquat 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 Residue related aspects of trade).

5.4 Residues in foods

The diquat product labels have broad crop groupings on the labels such as row crops, vegetables, market gardens and orchards. Diquat, by virtue of its use pattern groupings has historically lent itself to general commodity groupings in the MRL standard such as fruits and vegetables.

The current best practice is to approve label claims and establish MRLs based on the APVMA crop group guidance[6] and Codex Alimentarius (Codex) commodity groups. Therefore, it is appropriate that the current MRLs for fruits and vegetables and use patterns on labels reflect the appropriate crop groups and be reconsidered separately as part of this review.

5.4.1 Cropping situations

There are 4 distinct diquat use patterns in cropping situations:

5.4.1.1 Crop establishment or pre-emergence weed control

Applications can be made pre-sowing or post-sowing pre-emergence. The maximum pre-sowing crop and pasture establishment use rate is 0.368 kg ac/ha. The maximum post-sowing pre-emergence use rate is 0.8 kg ac/ha and includes the broad categories of row crops, vegetables and market gardens, in addition to the specific crops asparagus and rice. The submitted residues data on a wide range of crops demonstrated pre-emergence applications generally do not produce detectable residues in the harvested commodity.

5.4.1.2 Crop post-emergence directed or shielded weed control

Applications can be made as inter-row shielded sprays to emerged row crops and vines or as a directed spray around the base of tree crops. The applications can occur at any stage of the crop growth cycle although they generally occur before the crop canopy closes over. The maximum rates are 0.8 kg ac/ha for row crops, vegetables and market gardens, 0.28 kg ac/ha for hops, and 0.368 kg ac/ha for potatoes. The maximum rate for applications around the base of tree crops or between vines is 0.368 kg ac/ha.

The submitted residues data demonstrated that shielded sprays at early crop post-emergence and directed sprays around the base of trees crops generally do not result in detectable residues. Where detectable residues did occur in fruit from tree crops, the sampled fruit had either fallen and was directly sprayed or was deliberately dropped onto the sprayed ground. For some vegetable crop groups, the available residue data does demonstrate a potential for low but finite levels of diquat residues following directed post emergent use (see Vegetable crops).

[6] APVMA crop group guidance, available on APVMA website.

5.4.1.3 Crop or pasture post-emergence over the top weed control applications

Applications can be made over the top of plant and ratoon sugarcane and mature potato and cereal crops, the later 2 crops to assist digging and harvest. The maximum use rate is 0.23 kg ac/ha for sugarcane, 0.368 kg ac/ha for potatoes and 0.6 kg ac/ha for cereal crops. These applications to cereal crops are expected to result in detectable residues as the cereal head is exposed to the spray.

Diquat is also applied directly at rates of 0.276–0.368 kg ac/ha to lucerne, mixed pasture and grass pastures to assist in weed control for establishment and renovation, or to suppress kikuyu and paspalum pastures for over-sowing of winter feed. These applications are expected to result in detectable residues in the plant material, which is routinely grazed, noting the grazing Withholding Period (WHP) is one day.

5.4.1.4 Pre-harvest desiccation applications

Applications to assist plant desiccation as well as weed control prior to harvest are expected to result in significant residues in the crop grains and remaining dried plant material that is cut or grazed for feed. The Australian use rate for cereal, oilseed, pulse and sugar cane crops is 0.6 kg ac/ha while for poppies, potatoes and sweet potatoes the rate is 0.8 kg ac/ha.

5.4.2 Summary of diquat residues in submitted studies

The submitted studies are categorised below according to their crop grouping and the related use pattern on the diquat labels. The submitted residues data was comprehensive for some crops and crop groups such as peas, beans, oilseeds, potatoes, and cereals; however, for other crop groups, there was less available data, or no available data.

Table 12: Summary of use patterns, crop groups and residue studies submitted for assessment

Use pattern	Crop group	Submitted studies
Orchards and vineyards (including bananas) Avocado, custard apple, lychee, mango * Note: Berries other than grapes and pineapples will be considered against the row crop label claim	Pome	Apples
	Stone	Peaches
	Berries *	Grapes, strawberries, blueberries
	Assorted trop. and sub-trop. (edible peel)	Olives
	Assorted trop. and sub-trop. (inedible peel)	Bananas
	Citrus	None
	Tree nuts	None
Row crops, vegetables and market gardens	Bulb vegetables	Onions
	Brassica vegetables	Broccoli, cabbage, Chinese cabbage, Brussels sprouts

Use pattern	Crop group	Submitted studies
	Cucurbits	Cucumber
	Fruiting vegetables, other than cucurbits	Tomatoes, capsicums
	Herbs and spices	None
	Leafy vegetables	Lettuce
	Legume vegetables	Peas and beans
Sweet potato Asparagus	Root and tuber vegetables	Potato, radish, turnip, sugar beet carrot
	Stem and stalk vegetables	Celery, asparagus
Dry peas, dry beans, lentils, chickpeas, faba beans, lupins, mung beans, pigeon peas, soybean	Pulses	Peas, beans, lentils, field peas, soybeans
Winter cereals	Cereal grains	Wheat, barley, oats
Maize		Maize
Sorghum		Sorghum
Rice		Rice
Sugarcane	Sugarcane	Sugarcane juice
Linseed Poppies Canola Sunflower	Oilseeds	Cotton, linseed, peanuts, sesame, sunflower, rapeseed, poppies
Hops	Hops	Hops
Crop establishment	Pulses Cereal grains Oilseeds Pasture	See above
Lucerne Pasture (grass and mixed) Legume seed crops	Pasture	Lucerne, clover, grass, forage and fodder of peas, beans, pulses and soybeans, fodder and forage of cereals

5.4.3 Fruit crops

The current MRL for fruit crops, listed as 'Fruits' is LOQ (*0.05 mg/kg) includes all fruits on the labels from orchards (including bananas and vineyards), 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.

The following crops will be considered against the current label use pattern for orchards and vineyards (including bananas) claims: grapes, citrus, pome fruit, stone fruit, tree nuts, tropical fruit (edible peel), tropical fruit (inedible peel, except pineapple). Berries (other than grapes) and pineapples will be considered against the current label claim for row crops.

5.4.3.1 Pome fruit

The available diquat residue trials on pome fruit (apples) are summarised below. The maximum Australian use rate involves application around the base of trees at a rate of 0.368 kg ac/ha. Overseas trials were carried out using rates of 1.0–11.2 kg ac/ha, including one trial with 4.48 kg diquat dichloride/ha (Calderbank and Yuan, 1963; Anon, 1987). Single applications were made as sprays around the base of the tree, and in one trial applications were made directly to the bark of the tree in contravention of the current label instructions. Apples were harvested between 72 and 112 days after the application. In only one trial, at the rate of 6.7 kg ac/ha, were low finite residues (0.015 mg/kg) were detected in apples. In all other trials, residues were <LOQ. The LOQ was 0.01 mg/kg in all apple trials except for one which had a LOQ of 0.05 mg/kg. This data demonstrates that residues above the LOQ of 0.01 mg/kg should not occur in apples as a result of the current label use (0.368 kg ac/ha).

The available diquat residues data supports continued use in pome fruit orchards. The recommended entry into the MRL Standard 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.

5.4.3.2 Stone fruit

The available diquat residue trials on stone fruit (peaches) are summarised below. The maximum Australian use rate involves application around the base of trees at a rate of 0.368 kg ac/ha. No detectable residues were found in peach flesh harvested 28 or 52 days after 5 applications at rates of 0.39 to 0.9 kg ac/ha in 2 overseas trials (Swaine, 1981(a)). The LOQ was 0.01 mg/kg. This data demonstrates that residues above the LOQ (0.01 mg/kg) should not occur in peaches as a result of current rate (0.368 g ac/ha). While it is noted that only 2 peach trials are available for the stone fruit crop group, diquat residues data, which demonstrates that residues above the LOQ should not occur in other tree fruit crops, is supportive of this use in stone fruit.

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

- FP 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.

5.4.3.3 Berries and other small fruit

The available diquat residue trials on berries and other small fruit (grapes, strawberries, blueberries) are summarised below. The maximum Australian use rate to grapes involves application between the vines at 0.368 kg ac/ha. Seventeen overseas trials were conducted on grapes (Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; Kennedy, 1988(a); Anderson et al., 1994(a); Dick et al., 1995(a)), with detectable residues occurring in 2 trials where sampling occurred 2 days after application of 0.8 kg ac/ha (0.02, 0.016 mg/kg) and in the 4 trials where 3 applications of 1 kg ac/ha were made, and samples of dropped fruit (dropped 3–12 hours after the last application) were taken 14 days after the last application (0.03, 0.05, 0.06, 0.03 mg/kg). These rates are higher than the current Australian maximum use rate and the collection of fallen grapes is not normal practice. LOQs ranged from 0.01 to 0.05 mg/kg.

The maximum Australian label rate is up to 0.8 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). The use is pre-emergence or by shielded spray post emergence. No detectable residues of diquat were found in strawberry trials in and a blueberry trial with application rates of 0.4 to 1.4 kg ac/ha. LOQs were 0.01 to 0.05 mg/kg (Calderbank and McKenna 1964; Anon. 1981). In 3 additional strawberry trials summarised by the 2013 Joint FAO/WHO Meeting on Pesticide Residues (JMPR) residues were <0.05 mg/kg at 47–50 days after an inter-row directed spray at 0.85–0.92 kg ac/ha.

The available diquat 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 as follows noting the LOQ is many of the grape and strawberry trials was 0.05 mg/kg:

- FB 0018 Berries and other small fruits *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 berries and other small fruit.

5.4.3.4 Tropical and sub-tropical fruit with edible peel

The available diquat residue trials on tropical and sub-tropical fruit with edible peel (olives) are summarised below. The maximum Australian use rate involves application around the base of trees at a rate of 0.368 kg ac/ha. In 4 overseas olive trials single applications of rates from 0.24 to 0.78 kg ac/ha were made 6–17 days prior to sampling at either the ripening stage or maturity (Kennedy, 1987(a); Massey, 1987(a); Dick et al.,1995(b)). In 2 trials, ripening olives were sampled directly from the canopy and the whole fruit and extracted oil contained no detectable residues of diquat (LOQ 0.1 mg/kg for fruit, 0.05 mg/kg for oil). In the remaining 2 trials mature fruit lying on the ground at the time of treatment of 0.4 kg ac/ha, and collected 6–7 days later, contained diquat residues of 0.31 and 1.5 mg/kg. Collection of sprayed fruit would not be considered good agricultural practice. This data demonstrates that residues above the LOQ (0.1 mg/kg) should not occur in olives as a result of current rate (0.368 kg ac/ha). While it is noted that only 4 olive trials are available for the tropical fruit with edible peel crop group, diquat residues data which demonstrates that residues above the LOQ should not occur in other tree fruit crops is supportive of this use in tropical fruit with edible peel.

The available diquat residues data supports continued use in assorted tropical and sub-tropical fruits – edible peel. The recommended entries into the MRL Standard for are as follows noting that olives for oil production (SO 0305) will not be covered by the tropical fruit with edible peel group MRL:

- FP 0026 Assorted tropical and sub-tropical fruits – edible peel *0.1 mg/kg
- S0 0305 Olives for oil production *0.1 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 assorted tropical and sub-tropical fruits – edible peel.

5.4.3.5 Tropical and sub-tropical fruit with inedible peel

The available diquat residue trials on tropical and sub-tropical fruit with inedible peel (bananas) are summarised below. The maximum Australian use rate in orchards (which covers all tropical fruit with inedible peel, except pineapples) involves application around the base of trees at a rate of 0.368 kg ac/ha for the general use in orchards. There is a specific use on avocado, custard apple, lychee and mango at 27.6 g ai/100 L applied to ground cover beneath the trees. A second spray 14 days later may be required.

In 8 overseas trials on bananas 3 applications 28–33 days apart were made around the base of mature banana plants at rates of 0.15 to 0.6 kg ac/ha (Earl, 1993(b); Earl, 1994). Residues of diquat were not detected in bananas sampled immediately after the last application (LOQ 0.02 mg/kg). This data demonstrates that residues above the LOQ should not occur in banana as a result of current rate (0.368 kg ac/ha or 27.6 g ai/100 L). While it is noted that only banana trials are available for the tropical fruit with inedible peel crop group, diquat residues data, which demonstrates that residues above the LOQ should not occur in other tree fruit crops, is supportive of this use in tropical fruit with inedible peel, except for pineapple.

Residue data for diquat on pineapples have not been provided for the review and are not available in the JMPR evaluations. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops which may include pineapples. The use is pre-emergence or by shielded spray post emergence. The available banana data (0.15 to 0.6 kg ac/ha) did not address the application rate of 0.8 kg ai/ka and it is noted that crop physiology and agronomy for pineapple differs to bananas and other members of the tropical fruit with inedible peel crop group. As discussed in the risk assessment for Vegetable crops, there is a potential for residues to occur in crops following the current label use for row crops. It is therefore not appropriate to support the continued use of diquat on pineapples without specific residue data as a robust assessment of the potential for residues in pineapples cannot be performed.

The available diquat residues data supports continued use in tropical fruit with inedible peel, which was covered by the label claim for orchards and the specific use for avocados, custard apples, litchis and mangoes (2 application, 14 days apart at 27.6 ai/100L). Continued use in pineapples, which was covered by the row crop label claim is not supported due to a lack or residues data. The recommended entry into the MRL Standard for is:

- FP 0030 Assorted tropical and sub-tropical fruits – inedible peel {except Pineapple} *0.02 mg/kg

As the use on tropical fruit with inedible peel (except pineapples) is directed to weeds and not the trees, a harvest withholding period statement of 'Not Required when used as directed' is supported for assorted tropical and sub-tropical fruits – edible peel.

5.4.3.6 Citrus

The general use on orchards may include citrus. The maximum Australian use rate involves application around the base of trees at a rate of 0.368 kg ac/ha. No residues data for citrus has been submitted but owing to the nature of the use pattern (around the base of trees) and given the weight of evidence for other tree crops, diquat residues in citrus fruit at commercial maturity above the LOQ are not expected.

The available diquat residues data for other tree crops supports continued use in citrus orchards. The recommended entry into the MRL Standard for citrus fruit is:

- FP 0001 Citrus fruits *0.05 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.

5.4.3.7 Tree nuts

Some diquat product labels contain specific uses in hazelnuts, pistachios and walnuts and general use on orchards may also include tree nuts. The maximum Australian use rate involves application around the base of trees at a rate of 0.368 kg ac/ha. No residues data for tree nuts has been submitted but owing to the nature of the use pattern (to the base of trees) and given the weight of evidence for other tree crops, diquat residues in tree nuts at commercial maturity above the LOQ is not expected. For this reason the MRL of *0.05 mg/kg for diquat on tree nuts will remain in place.

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 tree nuts.

5.4.4 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.

The following crop groups will be considered against the current row crop, vegetables and market garden label claims: brassica vegetables, bulb vegetables, fruiting vegetables (cucurbits), fruiting vegetables (other than cucurbits), leafy vegetables, legume vegetables, root and tuber vegetables, stalk and stem vegetables and herbs and spices.

5.4.4.1 Bulb vegetables

The available diquat residue trials on bulb vegetables (bulb onions) are summarised below. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens which may include bulb vegetables. The use is pre-emergence or by shielded spray post emergence. Detectable residues of diquat were measured in 6 suitable overseas trials in bulb onions (Calderbank and McKenna, 1964; Anon., 1972; Edwards, 1977; Kennedy, 1984(a); Massey, 1987(b); Anderson and Lant, 1994(a); Anon., no date(a)). In one trial residues of 0.10 and 0.03 mg/kg were measured in samples taken 6–7 days after the last of 3 applications of 0.8 kg ac/ha. In another trial residues were found of 0.05, 0.04, 0.03 and 0.02 mg/kg in samples taken 15 days after single applications of 0.56–1.12 kg ac/ha. One trial had residues of 0.08 and 0.14 mg/kg 11 days after applications of 1.2 and

2.4 kg ac/ha, respectively. Another had residues of 0.06 mg/kg in the unbrushed onion when sampled immediately after an application of 0.3 kg ac/ha. Detectable residues of diquat were measured in 2 additional trials with residue up to 0.02 mg/kg in samples taken from zero to 14 days after an application of 0.9 kg ac/ha and residues up to 0.04 mg/kg in samples taken from zero to 21 days after the last of 3 applications of 0.75 kg ac/ha.

The highest residues reported in bulb onions, which was relevant to the Australian use rate of 0.8 kg ac/ha, was 0.10 mg/kg after 3 applications of 0.8 kg ac/ha and an MRL at 0.2 mg/kg is considered appropriate for bulb onions. It is noted that the available onion trials addressed the bulb only, and residues data for green onions (or the leaves of onions) is not available. The representative crops for the bulb vegetable crop group are bulb onions (from the bulb onion subgroup) and spring onion (from the green onion subgroup)[7]. The residue potential from the post emergent shielded spray use may be higher for green onions than bulb onions as the edible commodity for green onions is above ground.

The available diquat residues data supports continued use in the bulb onion subgroup, which includes bulb onions, shallots and garlic (among others). In the absence of residues data for spring onion or other members of the green onion subgroup, continued use in members of the green onion subgroup is not supported noting that finite residues may be expected and a robust assessment of the potential for residues in green onions cannot be performed without specific residues data.

The recommended entry into the MRL Standard for bulb onions is:

- VA 2031 Bulb onions 0.2 mg/kg

Although the high residue (HR) was observed at 6–7 days after application at 0.8 kg ac/ha (1×), a 'Not required when used as directed' withholding period is considered suitable for shielded spray application post emergence, noting also that lower residues were observed immediately after application and that an MRL has been recommended to cover the observed HR.

5.4.4.2 Brassica vegetables

The available diquat residue trials on brassica vegetables (broccoli, cabbage, Chinese cabbage, cauliflower and Brussels sprouts) are summarised below. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens which may include brassica vegetables. The use is pre-emergence or by shielded spray post emergence.

Overseas trials were conducted on broccoli and cauliflower, which are members of the flowerhead brassica subgroup as well as cabbage and Chinese cabbage which are members of the head brassica subgroup.

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[7] Crop group 009, Bulb vegetables, available on the APVMA website.

A single trial on Brussels sprouts was provided however that trial was considered to be unreliable. The representative crops for brassica vegetable crop group[8] are broccoli or cauliflower, head cabbage and Brussels sprouts.

In the trials conducted on broccoli, cauliflower, cabbage and Chinese cabbage, one to 3 applications were made at rates of 0.5 to 2.2 kg ac/ha. Samples were collected 7–50 days after the last application. Residues of diquat were not detected in any of these trials (LOQ 0.01 to 0.02 mg/kg)(McKenna, 1966; Edwards, 1977).

The available diquat residues data supports continued use in the specific brassica vegetables for which there is suitable residues data, namely broccoli, cauliflower, cabbage and Chinese cabbage. In the absence of residues data for Brussels sprouts, which is a representative crop, use in Brussels sprouts or the entire brassica vegetable crop group is not supported due to a lack of relevant residues data (for Brussels sprouts). The recommended entries into the MRL Standard for Brassica vegetables are:

- VB 0400 Broccoli *0.02 mg/kg
- VB 0041 Cabbages, head *0.02 mg/kg
- VB 0404 Cauliflower *0.02 mg/kg
- VB 0467 Chinese cabbage (type Pe-tsai) *0.02 mg/kg

As the use is pre-emergence or by shielded spray, a harvest withholding period statement of 'Not Required when used as directed' is supported for broccoli, cauliflower, cabbage and Chinese cabbage.

5.4.4.3 Fruiting vegetables (other than cucurbits)

The available diquat residue trials on fruiting vegetables, other than cucurbits (tomatoes, capsicums) are summarised below. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens, which may include fruiting vegetables. The use is pre-emergence or by shielded spray post emergence. In the single overseas capsicum (sweet pepper) trial residues of diquat were not detected in the whole fruit when applied once at 2.2 kg ac/ha and sampled 22 days later (LOQ 0.05 mg/kg; McKenna, 1966). In 2 overseas tomato trials, residues were not detected in whole fruit of tomatoes when applied one or 3 times at 0.6 kg ac/ha and sampled 6–7 days later, nor were residues detected when diquat was applied in overhead irrigation water at 0.1 ppm (LOQ 0.01 mg/kg; McKenna 1966). The 2013 JMPR considered additional residue data for tomatoes involving inter-row directed sprays for weed control (preharvest interval (PHI) 15 days) and concluded there is no expectation of residues above the LOQ (0.01 mg/kg; Edwards MJ, (1977).

The available diquat residues data supports continued use in fruiting vegetables (other than cucurbits) noting that residues data is available for the 2 representative crops of tomatoes and peppers.

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[8] Crop group 010: Brassica (cole or cabbage) vegetables, Head cabbages, Flowerhead cabbages, available on the APVMA website.

The recommended entry into the MRL Standard for Fruiting vegetables, other than cucurbits is as follows noting that the predominant LOQ in the available trials was 0.01 mg/kg:

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

As the use is pre-emergence or by shielded spray, a harvest withholding period statement of 'Not Required when used as directed' is supported for fruiting vegetables, other than cucurbits.

5.4.4.4 Leafy vegetables

The available diquat residue trials on lettuce are summarised below. Relevant data for radish leaves are also summarised below. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens which may include leafy vegetables. The use is pre-emergence or by shielded spray post emergence.

A number of overseas trials conducted on head lettuce or leaf lettuce were provided (McKenna, 1966; Edwards, 1977; Kennedy, 1984(a); Massey, 1987(c); Anderson and Lant, 1994(a)). In trials that involved one to 2 applications at rates approximate to the Australian rate (0.7–1 kg ac/ha), residues were 0.01 (2), <0.02, 0.07, 0.13, 0.23 and 0.91 mg/kg at a zero day PHI. In the same trials, residues were <0.01, 0.01, <0.02 (2), 0.03, 0.05 and 0.07 mg/kg at a 7–10 day PHI. It is noted that the post-emergence treatments in the trials did not involve shielded sprayer and therefore represent a worst case.

Residues in radish leaves at zero days after the last of 4 applications at 0.6 kg ac/ha were 0.03 mg/kg, and <0.01 mg/kg at 8 days after the last of 3 applications at the same rate (Calderbank and Yuan 1963).

While a HR of 0.91 mg/kg was observed in lettuce at a zero day PHI, that sampling time is not relevant to pre-emergent application, and it is considered that post-emergent shielded spray applications would not be made close to harvest and crops should not be directly contacted with diquat spray under normal agronomic practice. The samples lettuce and radish leaf samples collected 7–10 days after application are considered to represent the realistic worse case residue potential. The OECD MRL calculator recommends an MRL of 0.15 mg/kg based on the 7–10 day data. A MRL at 0.2 mg/kg is considered to be appropriate leafy vegetables noting that one relevant trial is from radish leaves (from the brassica leafy vegetable subgroup [9]).

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

- VL 0053 Leafy vegetables 0.2 mg/kg

As the use is pre-emergence or by shielded spray, a harvest withholding period statement of 'Not Required when used as directed' is supported for leafy vegetables.

[9] Crop group 13: Leafy vegetables (including Brassica leafy vegetables), available on the APVMA website.

5.4.4.5 Legume vegetables

The available diquat residue trials on legume vegetables (peas and beans) are summarised below. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens, which may include legume vegetables. The use is pre-emergence or by shielded spray post emergence. Overseas trials for peas and beans have been provided (Anon., no date(b); Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1972; Edwards, 1977; Anon., 1980(a); Culoto and de Mallmann, 1982; Swaine, 1983(a); Culoto, 1985(a); Kennedy, 1985(a); Kennedy, 1986(b); Massey, 1987(d); Anon., 1987; Earl, 1991(a); Earl and Hall, 1994; Roper, 1995(a,b); Roper, 1996). It was not always clear from the submitted trial information whether the peas and beans were harvested when succulent (legume vegetables), or dried (pulses) but given that the use on legume vegetables pre-emergence or by shielded spray post emergence, the pre-emergent trials on peas and beans are considered relevant.

For 8 overseas trials where a pre-emergence or post-emergence application was made to peas, no detectable residues of diquat were found in the pea seed, pods or stalks/vines (LOQ 0.05–0.1 mg/kg). Rates in these trials ranged from 0.14 to 1.12 kg ac/ha. In one trial with a pre-emergence application of 1.7 kg ac/ha residues of 0.06 mg/kg were measured but that residue would scale to below the LOQ of 0.05 mg/kg when corrected for the Australian application rate (0.8 kg ac/ha). In one trial on snap beans residues of diquat were not detected after an application of 2.24 kg ac/ha (LOQ 0.05 mg/kg). Samples were taken 22 days after application and although not stated, snap beans are routinely harvested green, therefore this trial represents the Australian use pattern of weed control for legume vegetables (when corrected for rate). Based on this data, the pre-emergence and post-emergence (shielded sprayer) use pattern where the maximum Australian rate is 0.8 kg ac/ha is not likely to result in detectable residues in peas and beans at commercial maturity.

The available diquat residues data supports 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-emergence or by shielded spray, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for legume vegetables.

5.4.4.6 Root and tuber vegetables

The available diquat residue trials on root and tuber vegetables (potato, radish, turnip, sugar beet and carrot) are summarised below. The maximum Australian label rate for potatoes is 0.368 kg ac/ha for post-emergence and pre-harvest weed control and 0.8 kg ac/ha for pre-harvest desiccation. The withholding period is 7 days for the pre-harvest desiccation application. Another use allows application to potatoes at 368 g ac/ha at 3–7 days before digging, while there is a pre-harvest desiccation use on sweet potatoes which allows application at 800 g ac/ha with a 14 day withholding period. Other root and tuber vegetables are covered by the general row crop and market garden pre-emergent or post emergent shielded spray application use at 0.8 kg ac/ha.

Twelve reports were submitted containing results of residues trials from Australia and overseas on potatoes (Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Swaine, 1982(a); Kennedy, 1984(a); Kennedy, 1987(b); Earl and Anderson, 1989(a); Earl, 1991(b,c); Anderson and Earl, 1993; Earl et al.,1993; Roper, 1995(c)). The majority of the trials were pre-harvest desiccation applications, although several pre- and post-emergence weed control application trials were also submitted. Residues in the pre-harvest desiccation trials were mainly below 0.02 mg/kg, although in one study mean residues of 0.06, 0.17 and 0.26 mg/kg occurred in tubers after an application of 0.84, 1.1 and 2.2 kg ac/ha, respectively. When scaled for the application rate of 0.8 kg ac/ha, the HR is 0.12 mg/kg. Residues of diquat in more recent reports were in the range <0.01 to 0.07 mg/kg in tubers sampled 4–44 days after 1–3 applications of 0.2 to 1.0 kg ac/ha, with most below the LOQ (0.01, 0.02 or 0.05 mg/kg).

The 2013 JMPR considered additional 16 European trials for a pre-harvest use on potatoes (residues ranging from <0.01–0.02 mg/kg, 0–15 days after treatment at approx. 1 kg ac/ha) along with data from the USA (that have been submitted for this review). The JMPR recommended an MRL of 0.1 mg/kg for diquat on potatoes for an approved use (good agricultural practice or GAP) similar to that registered in Australia (GAP from the USA: 0.56 kg ac/ha, PHI 7 days).

While no residues data is available for sweet potato, sweet potato and potato are both members of the same subgroup (Subgroup 016B, Tuberous and corm vegetables [10]) and therefore extrapolation from potato data to sweet potato is possible.

An MRL of 0.2 mg/kg is recommended for diquat on VR 0508 Sweet potatoes at the same level as the current MRL for VR 0589 Potatoes, which also remains appropriate, to cover the pre-harvest desiccation uses on these crops with 14 and 7 day withholding periods respectively. It is noted that a recommendation of the paraquat review for products containing paraquat and diquat for use on potatoes '3 to 7 days before digging and after tops have died down' was that application should occur '4–5 weeks before digging'. However, there are standalone diquat products that can be used on potatoes at up to 0.8 kg ac/ha 7 days before harvest.

Three reports were submitted that contain summary information of trials conducted on radish, turnip and sugar beet in Canada, Japan, Italy and the UK during the period 1962–75 (Calderbank and Yuan, 1963; McKenna, 1966; Edwards, 1977). Two trials on radish in Japan were pre-emergence weed control applications, the sugar beet trials were pre-harvest desiccation applications and the trials on radish and turnip in Canada were probably also pre-harvest desiccation applications, based on the PHI, however the use pattern was not stated in the report. No Australian trials were submitted.

No detectable residues of diquat occurred in tubers sampled zero to 96 days after one to 4 applications of rate from 0.4 to 4.4 kg ac/ha.

There were 13 overseas carrot trials conducted as pre-emergence and post-emergence weed control (Anon., no date(a); McKenna, 1966; Edwards, 1977; Kennedy, 1984(a); Anderson and Lant,1994(a): Massey, 1987(e)). Residues of diquat in these trials were generally <0.02 mg/kg, with a maximum of 0.07 mg/kg recorded in samples taken 14 days after an application of 1.0 kg ac/ha (1.25× the maximum label rate). The maximum residue recorded after application at 0.8 kg ac/ha (1× the maximum label rate) was 0.04 mg/kg in the same trial (14 day PHI).

[10] Crop group 016: Root and tuber vegetables, available on the APVMA website.

In another trial, residues were all <0.02 mg/kg in samples taken one, 7, 13 and 20 days after an inter-row weed control application of 0.8 kg a.i/ha. The PHI in all these trials ranged from one to 123 days and the shorter intervals would not reflect typical agronomic practice where application as a pre-emergence weed control is earlier in the crop growth cycle, or via shielded sprayer later in the growing cycle.

Diquat residues in other root and tuber vegetables after pre-emergent or post emergent shielded spray application will be covered by an MRL recommended at 0.1 mg/kg in conjunction with a 'Not required when used as directed' harvest withholding period (the sugar beet MRL at 0.1 mg/kg will be deleted). This group MRL will cover the HR of 0.07 mg/kg observed in carrots after a pre-emergence application.

The supported/recommended MRLs are:

- VR 0589 Potato 0.2 mg/kg
- VR 0075 Root and tuber vegetables {except Potato; Sweet potato} 0.1 mg/kg
- VR 0508 Sweet potato 0.2 mg/kg

5.4.4.7 Stalk and stem vegetables

The available diquat residue trials on stalk and stem vegetables (celery and asparagus) are summarised below. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens, which may include stalk and stem vegetables. The use is pre-emergence or by shielded spray post emergence. There is also a specific use on asparagus prior to spear emergence at 0.28 kg ac/ha.

A single trial on celery was submitted initially and no relevant data was available in the JMPR evaluations (McKenna RH, 1966). No detectable residues occurred in celery stalks sampled 36 days after a single application of 2.22 kg ac/ha. However, the LOQ for the method was not reported and the trial is not considered to be reliable.

In response to the initial consultation, Syngenta submitted 2 European GLP residue studies on asparagus. In the first study, diquat was applied to the soil for control of weeds at 800 g ac/ha with residues <0.05 mg/kg (n = 2) in the spears at 3 – 4 days after treatment. In the second study, diquat was applied prior to spear emergence at 747 – 760 g ac/ha with residues in the spears <0.01 mg/kg (n = 2) at 11 – 20 days after treatment. Asparagus is only one representative crop for stalk and stem vegetables, with the other being celery and globe artichoke. [11] The single trial provided previously for celery was considered not to be reliable. There is insufficient data to support the general use on the whole stalk and stem vegetable crop group. The general use is supported for asparagus only, along with the specific asparagus use prior to spear emergence.

- An MRL of *0.05 mg/kg is recommended for VS 0621 Asparagus in conjunction with a harvest withholding period of "Not required when used as directed".

[11] Crop group 017: Stalk and stem vegetables, available on the APVMA website.

5.4.4.8 Cucurbits

Residue data for diquat on cucurbits were not provided for the initial review and were not available in the JMPR evaluations. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens, which may include cucurbits. The use is pre-emergence or by shielded spray post emergence.

In response to the initial consultation, Syngenta submitted 5 European GLP residue studies conducted on field (5 trials) and protected (6 trials) cucumbers. In 11 trials involving inter-row application at 953 – 1232 g ac/ha (1.2× - 1.5×) highest residues at 0 – 8 days after treatment were <0.01 (7), 0.02 (2), <0.05 and 0.05 mg/kg. Residues were detected both in the field and in protected situations. The OECD MRL Calculator recommends an MRL of 0.09 mg/kg (n = 11, STMR = <0.01 mg/kg). Cucumber is a representative crop for cucurbits, but data for cantaloupe and summer squash are also required to support use on the whole crop group. Given that detectable residues were found in cucumber, the use is supported for cucumber only, not the cucurbit crop group.

- An MRL of 0.1 mg/kg is recommended for VC 0424 Cucumber in conjunction with a harvest withholding period of "Not required when used as directed".

5.4.4.9 Herbs and spices

Residue data for diquat on herbs and spices have not been provided for the review and are not available in the JMPR evaluations. The maximum Australian label rate is up to 0.8 kg ac/ha for row crops and market gardens, which may include herbs and spices. The use is pre-emergence or by shielded spray post emergence. However, it is not appropriate to support the continued use of diquat on herbs and spices without specific residue data as residue data for other crops including leafy vegetables have indicated a potential for finite residues from the current use in row crops and market gardens for some crop groups. Without residues data for herb and spice crops, a robust assessment of the potential for residues in the herb and spice crop groups cannot be performed and these uses are not supported.

5.4.4.10 Pulses

The available diquat residue trials on pulses (lentils, field peas, soybean) are summarised below. Additional data for peas and beans, including dried, are also summarised below.

The maximum Australian label rate for pre-harvest desiccation of a range of pulse crops is 0.6 kg ac/ha. The specified pulse crops for the pre-harvest desiccation use are dry beans, dry peas, lentils, chickpeas, faba beans, lupins, mung beans, pigeon peas and soya beans. The current Australian MRL for Pulses is 1 mg/kg and the label withholding period range from nil (0 days) to 4 days, depending on the pulse crop.

Detectable residues generally occurred in the seeds, pods, or stalks/vines (haulm) from trials where the application of diquat occurred as a pre-harvest desiccant. Application rates in these trials ranged from 0.265 to 1.54 kg ac/ha (McKenna, 1966; Anon., 1972; Anderson, 1990; Dodsworth, 1990; Dick et al., 1995(c,d); Roper, 1995(d); Roper, 1996). However, in 5 trials conducted no detectable residues occurred in pea seed sampled 5–17 days after one or 2 applications of 0.6 kg ac/ha (Dick et al., 1995(c)). Similarly, in another 3 trials no detectable residues occurred in pea seed sampled 4 days after one application of 0.265 or 0.530 kg ac/ha.

In another 6 trials dry peas sampled 4 days after one application of 0.42 kg ac/ha (0.7× the current rate), residues of 0.05, 0.05, 0.09, 0.11, 0.40 and 0.56 mg/kg were observed (Roper, 1995(c); Roper, 1996). This last result was the HR obtained in pea seed from all the trials submitted and is calculated to be 0.8 mg/kg when scaled for the Australian application rate (0.6 kg ac/ha). In trials where the application was at the Australian maximum label rate for pre-harvest desiccation treatments of 0.6 kg ac/ha, diquat residues ranged from <0.02 to 0.10 mg/kg. The shortest PHI in these trials was zero days, where sampling occurred immediately after application (Anderson, 1990).

In dried beans, residues of diquat were not detected (LOQ of 0.02–0.05 mg/kg) in 75 determinations made in samples of seed taken 3–12 days (pre-harvest desiccation) or 55–123 days (pre- and post-emergence) after a single application in the range of 0.14 to 1.12 kg ac/ha. In other samples, finite residues were however observed in dried beans with concentrations ranging from 0.03 to 0.66 mg/kg (32 determinations) after an application in the range of 0.3 to 1.0 kg ac/ha.

No Australian trials for other pulses were submitted; however, overseas trials were available for lentils and soya beans. In all the trials, single applications of diquat were made as a pre-harvest desiccation treatment. In trials on lentils at rates approximating the Australian maximum use rate of 0.6 kg ac/ha, 8 sites had applications of 0.55 kg ac/ha from zero to 7 days prior to harvest. No detectable residues (LOQ of 0.05 mg/kg) were found in seed at 4 sites, and at the remaining sites residues of 0.07, 0.36 and 1.1 mg/kg were found in seed sampled immediately after application (zero day PHI) and residues of 0.04, 0.07 and 0.28 mg/kg were found in seed sampled 7 days after application (Dodsworth, 1990). In soya bean trials the range of residues from applications made approximating the Australian maximum rate of 0.6 kg ac/ha, excluding the days zero to 2 samples, was <0.01–0.16 mg/kg (rates of 0.56 to 0.8 kg ac/ha and PHI of 5–10 days). At zero days residues in seed were 0.62–0.63 mg/kg after application at 0.6 kg ac/ha or up to 0.91 mg/kg in the same trials after application at 0.8 kg ac/ha (Calderbank and McKenna, 1964; Anon., 1972; Swaine, 1982(b); Massenot and Culoto, 1985; Kennedy, 1986(c); Fujie, 1988(b); Anderson and Barnaud, 1995).

Additional Canadian studies on pulses were considered in 2018 by the Joint FAO/WHO Meeting on Pesticide Residues (JMPR, 2018) and have been provided in full for this review. Residues in beans dry after treatment at the Canadian GAP (0.55 kg ac/ha for pre-harvest desiccation, sampling 4–5 day PHI) were 0.01, 0.012, 0.019, 0.040, 0.044, 0.15, 0.18 (2) and 0.35 mg/kg. Residues in chickpeas after treatment at the Canadian GAP (0.41 kg ac/ha for pre-harvest desiccation, 4–5 day PHI) were 0.070, 0.10, 0.16, 0.18, 0.24, 0.26, 0.32, 0.38 and 0.58 mg/kg. Residues in lentils after treatment at the Canadian GAP (0.55 kg ac/ha for pre-harvest desiccation, 4–5 day PHI) were 0.052, 0.070, 0.10, 0.16, 0.18, 0.21, 0.33 and 0.57 mg/kg. Residues in dry peas after treatment at the Canadian GAP (0.55 kg ac/ha for pre-harvest desiccation, 4–5 day PHI) were 0.014, 0.020, 0.038, 0.054, 0.061 and 0.13 mg/kg.

In response to the initial consultation, Syngenta submitted additional data for pulses, to provide further support for these uses including in relation to trade.

In 12 North American GLP on dry bean trials, residues at 3 – 4 days after application at 530 – 583 g ac/ha were <0.01 (6), 0.012, 0.016, 0.035, 0.036, 0.187 and 0.248 mg/kg.

In 8 European GLP dry bean trials, residues at 3-5 days after application at 600 g ac/ha were <0.01, 0.01, 0.02, 0.03, 0.04, 0.08, 0.09 and 0.10 mg/kg.

In 4 Brazilian GLP dry bean trials involving a pre-planting application at 400 g ac/ha and a pre-harvest application also at 400 g ai/ha (7 days before harvest) residues were <0.05 (3) and 0.12 mg/kg.

In 3 non-GLP trials on lupins from the UK, residues at 9 – 13 days after a desiccation application of diquat at 600 – 1000 g ac/ha were 0.17, 0.40 and 0.42 mg/kg.

In 8 North American trials on dry peas, residues at 4 – 5 days after application at 549 – 566 g ac/ha were <0.01 (2), 0.012, 0.016, 0.018, 0.023, 0.026 and 0.027 mg/kg.

The available diquat residues data supports continued use in pulses. There is a plethora of diquat residues data available relevant to the currently registered uses on pulses and the HR associated with the desiccation use (with a 4 day PHI) was 0.8 mg/kg in dried peas (scaled for the Australian rate). The supported MRL is:

- VD 0070 Pulses 1 mg/kg

A 'Not required when used as directed' withholding period would be suitable for the shielded spray under the general vegetable use. The supported harvest withholding period for pre-harvest desiccation of all pulse crops with this use is 4 days to reflect the time required for effective desiccation or weed control and the sampling period in the more recent pulse trials.

5.4.5 Cereals

5.4.5.1 Winter cereals

The Australian winter cereal maximum use rate is 0.6 kg ac/ha for pre-harvest weed control. The withholding period is 'Not required when used as directed'. Current labels do not specify individual winter cereals for this use pattern. The current Australian MRLs are Wheat, Rye and Triticale at 2 mg/kg, and Barley and Oats at 5 mg/kg, which are the crops which will be considered here as MRLs were not previously established for other cereal crops which may be considered as a 'winter cereal'. The 2018 JMPR considered pre-harvest cereal use patterns with withholding periods of 'Not required when used as directed' and concluded that at least 4 days after treatment would be required for effective weed control and crop dry down.

The submitted residues data for winter cereals was described mostly as pre-harvest desiccation applications (Barrett et al., no date; Calderbank A and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1969; Anon., 1970(a); Anon., 1972; Ward, 1978; Anon., 1980(b); Swaine, 1982(d,e); Swaine, 1983(b); Kennedy, 1984(b); Kennedy, 1986(d); Laws et al, 1987; Fujie, 1988(c); Culoto, 1977; Benet and Massenot, 1993; Anderson et al, 1994(b); Anderson and Dack, 1994; Anderson and Lant, 1994(b); Anderson and Bonfanti, 1995; Anderson et al, 1995(a); Anon., 1996). The Australian winter cereal use pattern is a weed control application of diquat when the plants are fully mature. These 2 use patterns differ very little in timing and from a residues perspective are indistinguishable.

Residues in wheat grain at levels greater than the current Australian MRL of 2 mg/kg (up to 2.3 mg/kg) occurred in 2 trials 3–4 days after applications of 0.8 and 0.84 kg ac/ha (1.3–1.4× the maximum rate) and 4 times in trials after an application of 0.6 kg ac/ha (up to 2.67 mg/kg at zero day PHI). The zero day PHI samples, however, were harvested immediately after application, which is not considered to be typical agronomic practice. At the next sampling point in those trials addressing the rate of 0.6 kg ac/ha of 4 days after application, residues had declined to between 0.17 and 0.56 mg/kg. In other trials diquat residues were in the range of <0.05 to 0.40 mg/kg in samples of grain harvested 8 days after an application of 0.6 kg ac/ha.

Additional Australian trials on wheat were considered by the 2018 JMPR and have been provided in full for this review. Residues of diquat in wheat grain at 2–4 days after application at approximately 0.6 kg ac/ha were 0.20, 0.28, 0.41, 0.45, 0.56, 0.57, 0.63 and 0.78 mg/kg. The OECD MRL Calculator recommends an MRL of 1.5 mg/kg (STMR = 0.51 mg/kg, n = 8) based on this dataset.

The current MRL of 2 mg/kg for diquat on wheat remains appropriate. Similarly, the MRLs for diquat on rye and triticale (which are in the same crop subgroup as wheat in the APVMA crop group guidelines [12]) should also remain at 2 mg/kg.

Diquat residues in barley grain tended to be higher than those in wheat. In a trial conducted at the Australian maximum use rate (0.6 kg ac/ha) had 3 Day zero results of 5.1, 5.12 and 5.7 mg/kg; however, by the next sampling at Day 4 residues had all declined to 1.5 mg/kg or less. In trials carried out more recently, one application of 0.8–0.944 kg ac/ha was applied and grain sampled one, 3 and 4 days later. Diquat residues ranged from 0.98 to 3.6 mg/kg. At 4 days residues in these more recent trials were 0.98, 1.1, 1.5 and 1.8 mg/kg.

Additional Australian trials on barley were considered by the 2018 JMPR and have been provided in full for this review. Residues of diquat in barley grain at 2–4 days after application at approximately 0.6 kg ac/ha were 0.15, 0.49, 0.53, 1.1, 2.0, 2.0 and 2.1 mg/kg.

The combined dataset based on the more recent trials and those evaluated by the 2018 JMPR is 0.15, 0.49, 0.53, 0.98, 1.1, 1.1, 1.5, 1.8, 2.0, 2.0 and 2.1 mg/kg. The OECD MRL Calculator recommends an MRL of 4 mg/kg (STMR = 1.1 mg/kg, n = 11). The current MRL of 5 mg/kg for diquat on barley remains appropriate noting it is equal to the Codex MRL, which was supported by JMPR in 2019.

In 2 of the more recent oat trials where one application was made at 0.8 kg ac/ha and grain sampled one, 3 and 4 days later, diquat residues ranged from 0.75 to 2.1 mg/kg. At 4 days residues were 0.75 and 0.90 mg/kg in these trials. Additional Australian data for diquat on oats were considered by the 2018 JMPR and have been provided for this review. Residues of diquat in oat grain at 2–4 days after application at approximately 0.6 kg ac/ha were 0.26, 0.41, 0.41 and 0.46 mg/kg.

The combined dataset for oats based on the more recent trials and those evaluated by the 2018 JMPR is 0.26, 0.41, 0.41, 0.46, 0.75 and 0.90 mg/kg. The OECD MRL Calculator recommends an MRL of 2 mg/kg (STMR = 0.44 mg/kg, n = 6). The current MRL for diquat on oats at 5 mg/kg should be replaced with an MRL at 2 mg/kg.

The supported MRLs are:

- GC 0640 Barley 5 mg/kg
- GC 0647 Oats 2 mg/kg

[12] Crop group 020: Cereal grains, available on the APVMA website.

- GC 0650 Rye 2 mg/kg
- GC 0653 Triticale 2 mg/kg
- GC 0654 Wheat 2 mg/kg

The current withholding period for winter cereals is nil. This should be replaced with a withholding period of 4 days to account for the period required for effective weed and crop dry down and the above MRL recommendations which were based on a 4 day PHI. Labels with the winter cereal use pattern should specify the crops as barley, oats, rye, triticale and wheat. The broad term of winter cereals should be removed from product labels as it does not align with the APVMA crop group guidance and replaced with specific claims for barley, oats, rye, triticale and wheat.

5.4.5.2 Alternative use pattern for wheat and oats

For wheat and oats there is an alternative use pattern that allows application at 140 g ac/ha between the 4 leaf stage (for wheat) or 3 leaf stage (for oats) up to early tillering. In Australian wheat trials considered by the JMPR (2018) and provided in full for this review, residues in wheat grain after 2 applications at approximately 140 g ac/ha with the first at BBCH 24–29 and the second at BBCH 24–52 were 0.04, 0.14, 0.22, 0.26, 0.28, 0.29, 0.30 and 0.34 mg/kg. Similarly for oat grain with the first application at BBCH 24 and the second at BBCH 24–45 residues were 0.13, 0.13, 0.19 and 0.21 mg/kg. (end of tillering = BBCH 29; for wheat the HR was observed when the last application was at BBCH 26, for oats the HR was observed when the last application was at BBCH 25). The MRLs recommended above for wheat and oats for the pre-harvest use will cover the residues expected for this alternative over the top use. The MRLs should also be sufficient to cover crops treated for pre-harvest weed control as well as by this alternative use pattern.

The MRLs recommended above will also cover crop establishment uses for wheat, barley, oats, rye and triticale.

In response to the initial consultation, Syngenta submitted additional overseas data for wheat and oats, to provide further support for these uses including in relation to trade.

In 6 GLP trials conducted on wheat in Brazil, a pre-planting application to wheat at 700 g ac/ha resulted in residues <0.01 mg/kg (n = 6) in grain at harvest.

In a GLP trial conducted on wheat in the UK, application at 800 g ac/ha at 4 days prior to harvest resulted in residues in grain of 0.3 mg/kg.

In two GLP trials conducted on oats in the UK, application at 800 g ac/ha at 4 days prior to harvest resulted in residues in grain of 0.56 and 1.0 mg/kg.

The new wheat and oat data are all within previously recommended MRLs which remain appropriate in conjunction with a 4 day harvest withholding period for the desiccation uses, and a harvest withholding period of “Not required when used as directed” for the other uses.

5.4.5.3 Sorghum and millet

The Australian maximum label rate for use on sorghum is 0.6 kg ac/ha for pre-harvest desiccation. There is also a use at crop establishment at 368 g ac/ha for sorghum and millet. The current Australian MRL for Sorghum is 2 mg/kg, there is no MRL currently established that would cover millet.

Pre-harvest desiccation trials on sorghum were submitted (Anon., 1969; 1970; Fujie, 1988). No Australian trials were submitted.

Diquat residues in sorghum grain were <0.05 to 16.1 mg/kg after pre-harvest applications (PHI zero to 30 days) in the range 0.2 to 1.2 kg ac/ha, although only 6 of the 146 results recorded were greater than 2 mg/kg. The HR was at a 15 day PHI. The lack of reported trial information in these sorghum studies presents difficulties in obtaining field related explanations for the high results, or to have confidence in the results.

In response to the initial consultation, Syngenta re-submitted overseas sorghum residue studies that were already considered in the initial APVMA review. While the resubmitted sorghum residue study was conducted under GLP and resulted in residues below the current MRL of 2 mg/kg at 7-10 DAT, it was conducted overseas in 1987 and involved only 3 trial sites. APVMA residue guidelines indicate that 6 residue trials (if deemed acceptable) are normally required to support a permanent MRL for sorghum. In addition, no Australian trials are available with the other previously considered overseas sorghum studies conducted prior to 1970.

The available data for sorghum suggests that the current MRL of 2 mg/kg may not be appropriate. Is not possible to recommend a suitable MRL for diquat on sorghum at this time, given the lack of details for the trials with residues above the MRL. The pre-harvest desiccation use of diquat on sorghum is not supported.

At the end of the phase out period, the sorghum MRL should be replaced with an MRL at *0.05 mg/kg to cover use at crop establishment, noting the results of the pre-emergent trials on rice and maize where residues were <0.05 mg/kg. Similarly, an MRL of *0.05 mg/kg is also supported for GC 0646 Millet for the crop establishment use. The supported withholding period for this use is ‘Not required when used as directed’.

5.4.5.4 Maize

The Australian maximum use rate on maize 0.368 kg ac/ha for pre-emergence weed control. The current Australian MRL for maize is 0.1 mg/kg.

Pre- and post-emergence weed control and pre-harvest desiccation trials on maize were submitted (Kennedy, 1986(d); Anderson and Bonfanti, 1995; Anderson and Lant, 1994(b)). No Australian trials were submitted.

Four overseas trials involved application at 0.28–1.12 kg ac/ha with samples collected at 68–149 days after application. Diquat residues in maize were <LOQ (0.05 mg/kg) in these trials when applications were made as pre-emergence and post-emergence weed control applications. The current MRL for diquat on maize at 0.1 mg/kg will be replaced with an MRL at *0.05 mg/kg.

The recommended MRL is:

- GC 0645 Maize *0.05 mg/kg

The recommended withholding period for this crop establishment use is 'Not required when used as directed'.

5.4.5.5 Rice

The Australian maximum use rate on rice is 368 g ac/ha pre-emergence or 600 g ac/ha for preharvest desiccation. The current Australian MRLs are rice at 5 mg/kg and rice polished at 1 mg/kg.

Two trials were conducted in Australia, with additional trials conducted in Brazil, Japan and Italy (Kennedy, 1986(e); Laws et al, 1987; Anderson et al, 1995(b)). The treatments in the submitted trials on rice were as pre- and post-emergence weed control and pre-harvest desiccation applications. Only the pre-emergence weed control trial (where residues were <0.05 mg/kg) and the pre-harvest desiccation trials are consistent with Australian GAP.

For the pre-harvest desiccation trials residues in whole grain were in the range <0.05 to 13 mg/kg after applications of 0.22 to 1.5 kg ac/ha and a PHI of 5–37 days. In pre-harvest desiccation trials where application rates were at the Australian maximum rate of 0.6 kg ac/ha, residues (mg/kg) were 0.90, 5.2, 0.88 – 3.0, $\bar{x}$ = 2.1 (n=5), 1.3, and 1.3–3.6, $\bar{x}$ = 2.1 (n=4). Residues in husked grain from pre-harvest desiccation applications were in the range <0.05 to 1.5 mg/kg after applications in the range of 0.28 to 1.0 kg ac/ha, although the HR of 1.5 mg/kg was present after a lower application rate of 0.3 kg ac/ha.

The available data for rice suggests that the current MRLs of 5 mg/kg for rice and 1 mg/kg for polished rice may not be appropriate for the pre-harvest desiccation use. Is not possible to recommend a suitable MRL for diquat on rice for the pre-harvest desiccation use at this time, given the lack of details for the trials with residues above the MRL. It is noted that finite MRLs for rice have not been established overseas except for a brown rice MRL in Japan at 0.03 mg/kg. The pre-harvest desiccation use of diquat on rice is no longer supported.

In 2 pre-emergent trials, residues in rice at harvest were <0.05 mg/kg after an application at 0.464 kg ac/ha at 5 days prior to sowing. This pre-emergent use pattern for rice therefore can be supported from a residues perspective.

At the end of the phase out period the rice and polished rice MRLs should be replaced with an MRL at *0.05 mg/kg for rice to cover the pre-emergent use pattern.

5.4.6 Oilseeds

The available diquat residue trials on oilseeds (cotton, rapeseed, sunflower, linseed and poppies) are summarised below.

5.4.6.1 Cotton

The maximum Australian use rate on cotton is for a pre-harvest application at 0.6 kg ac/ha when 85% of the bolls are open with a withholding period of 'Not required when used as directed'. There is also a use at crop establishment at 368 g ac/ha.

A summary of a single trial on cotton was submitted (Calderbank and Yuan, 1963). The PHI was not stated but the applications were as pre-harvest desiccation treatments. Residues were <LOQ (not stated) after a single application of 0.64 kg ac/ha, similar to the Australian maximum use rate. Detectable residues occurred at higher rates (0.84–1.68 kg ac/ha). The current Australian MRL is Oilseeds at 5 mg/kg. A single residue trial lacking details

on methods and PHI is not sufficient for a robust assessment of the residues potential and does not support a use on a major export commodity such as cotton given also the late application timing. It is noted that the 1994 JMPR indicated no new residue data for cotton were available and data submitted to the 1972 JMPR were not re-submitted. The 1994 JMPR withdrew the previous MRL recommendation for cotton seed. The continued pre-harvest use of diquat on cotton was initially not supported due to a lack of relevant residues data for cotton seed.

In response to the initial consultation, Syngenta submitted a non-GLP Australia residue study on cotton along with a GLP study conducted in Brazil.

The Australian study (2 trials) involved application of diquat at 184 g ac/ha at 7 days before harvest. Residues in seed at harvest were <0.10 mg/kg (n = 2). It is not possible to scale up residues below the LOQ to the required application rate. It is also noted that only 2 cotton residue trials are available involving application close to harvest when APVMA residue guidelines suggest that up to 8 trials are normally required for cotton.

The Brazilian study (4 trials) involved application at 700 g ac/ha at 2 days before planting. Residues in seed at harvest were <0.01 mg/kg (n = 4).

The pre-harvest desiccation use of diquat on cotton is still not supported due to a lack of relevant residues data for cotton seed. Syngenta have also proposed that residue data from other oilseed crops could be used in support of the pre-harvest use on cotton. However, cotton is in its own subgroup in the APVMA crop group guidelines and would require specific data for this use close to harvest. At the end of the phase out period an MRL of *0.05 mg/kg will be established for SO 0691 Cotton seed to support the alternative use at crop establishment as new data for cotton and previously submitted data for other crops (rice, maize and peanuts) has indicated residues are not expected at harvest for this use.

The appropriate withholding period for this supported crop establishment use in cotton is ‘Not required when used as directed’.

The recommended MRL for diquat use at cotton crop establishment is:

- SO 0691 Cotton seed *0.05 mg/kg

5.4.6.2 Peanuts

The use on peanuts is at crop establishment at 368 g ac/ha with a harvest withholding period of ‘Not required when used as directed’.

One trial summary on peanuts was submitted (Williams, 1989). Although not stated it was probably a post-emergence weed control application. No detectable residues (<0.01 mg/kg) were found in the kernels or the nut in the shell 109 days after an application of 0.09 or 0.112 kg a.i/ha.

Although the available data for peanuts is weak, data for other crops (rice and maize) also suggest that residues are not expected at harvest. An MRL of *0.05 mg/kg is recommended for SO 0697 Peanut to cover this use. The supported harvest withholding period is ‘Not required when used as directed’.

The recommended MRL for diquat use on peanuts at crop establishment is:

- SO 0697 Peanut *0.05 mg/kg

5.4.6.3 Safflower

The use on safflower is at crop establishment at 368 g ac/ha with a harvest withholding period of 'Not required when used as directed'.

Although data for safflower is not available, data for other crops (peanuts, rice and maize) suggest that residues are not expected at harvest following a pre-emergent use. An MRL of *0.05 mg/kg is recommended for SO 0699 Safflower seed to cover this use. The supported harvest withholding period is 'Not required when used as directed'.

The recommended MRL for diquat use on safflower at crop establishment is:

- SO 0699 Safflower seed *0.05 mg/kg

5.4.6.4 Sunflower

The maximum Australian label rate for use on sunflower is for application at up to 0.6 kg ac/ha at 7–14 days before harvest, noting the harvest withholding period is 4 days.

Eight reports were submitted which contained results of eighteen trials conducted on sunflowers (Anon., no date(c); Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1970(b); Anon., 1972; Anderson et al, 1995(c); Anderson and Renard, 1995(b)). One trial was conducted in Australia. The sunflower trials were all conducted at pre-harvest desiccation treatments. Residues of diquat in sunflower seed were in the range <0.05 to 1 mg/kg, after applications of 0.28 to 1.68 kg ac/ha. Eight trials had a single application of 0.6 kg ac/ha applied. Residues in the whole seed, which were calculated from the measured residues in oil and cake, were in the range 0.08 to 0.54 mg/kg with a PHI of 5–7 days. It is noted that the 2013 JMPR considered some of these studies submitted for review along with additional European sunflower studies and recommended an MRL of 0.9 mg/kg based on a GAP of 0.6 kg ac/ha, PHI 6 days (in the additional 5 JMPR trials matching this GAP residues in seed were <0.05–0.10 mg/kg). The combined data set for sunflower seed at 5–7 days after application at approximately 0.6 kg ac/ha is <0.05, 0.06, 0.06, 0.07, 0.08, 0.09, 0.10, 0.11, 0.11, 0.15, 0.19, 0.41, 0.46 and 0.54 mg/kg. The OECD MRL calculator recommends an MRL of 0.9 mg/kg (n = 14, STMR = 0.11 mg/kg). The current Australian MRL is Oilseeds at 5 mg/kg. A diquat sunflower MRL of 1 mg/kg is appropriate based on this data in conjunction with a 7 day withholding period instead of the currently registered withholding period of 4 days.

The available diquat residues data supports continued use sunflowers with a 7 day harvest withholding period. The recommended MRL is:

- SO 0702 Sunflower seed 1 mg/kg

5.4.6.5 Linseed

The maximum Australian label rate for use of diquat on linseed is for a pre-harvest desiccation application at up to 0.6 kg ac/ha when the majority of seed head are mature. A harvest withholding period is not specified.

Nine reports were submitted, which contained results of 18 trials conducted on linseed; however, one report, which measured residues in cake and oil only, was not considered further (Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1972; Earl and Anderson, 1989(b); Anderson and Elsworth, 1994; Anderson and Moons, 1995; Anderson and Renard, 1995(a), Dick et al., 1995(f)). No Australian trials were submitted. Two trials were conducted as post-emergence weed control treatments (no detectable residues occurred), and the remainder were pre-harvest desiccation treatments, which is Australian GAP. For the pre-harvest desiccation trials, the range of diquat residues in the seed was <0.05 to 5.5 mg/kg 7–16 days after an application of 0.07 to 2.24 kg ac/ha (scaled HR 2.75 mg/kg). After applications approximating the Australian maximum rate of 0.6 kg ac/ha, residues were <0.05 to 3.9 mg/kg. The available linseed trials did not address a sampling time less than 7 days. The current Australian MRL is Linseed at *0.01 mg/kg should be increased to 5 mg/kg.

The available diquat residues data supports continued use in linseed. The recommended MRL is:

- SO 0693 Linseed 5 mg/kg

Current labels do not specify a harvest withholding period for linseed. A 7 day harvest withholding period is recommended for linseed in line with the sampling times from the available residue trials.

5.4.6.6 Canola (rapeseed)

The maximum Australian label rate for use on canola is for a pre-harvest desiccation application at 0.6 kg ac/ha in conjunction with a 4 day harvest withholding period.

Seven reports of rapeseed residues trials were submitted (McKenna, 1966; Anon., no date(c); Anon., 1972; Anon., 1980(a); Swaine, 1981(b); Kennedy, 1984(c); Kennedy, 1988(b)). No Australian trials were submitted. Applications in all the trials were made as pre-harvest desiccation treatments. Diquat residues in rapeseed were in the range <0.05 to 1.5 mg/kg, from applications of 0.28 to 3.8 kg ac/ha, although most results were less than 1 mg/kg. In trials where applications of 0.6 kg ac/ha were applied 5–20 days prior to harvest all residues were <0.05 to 0.48 mg/kg.

Additional data for diquat on rape seed is available from the 2013 JMPR. Residues in rape seeds from trials conducted in Europe approximating German GAP (0.6 kg ac/ha, PHI 5 days) were (n=16): 0.02, 0.03, 0.03, 0.05, 0.06, 0.07, 0.08, 0.10, 0.12, 0.22, 0.27, 0.33, 0.38, 0.42, 0.44, 0.45 mg/kg. In trials approximating GAP in the USA (0.56 kg ac/ha, PHI 7 days) total residues in rape seeds were (n=9): 0.06, 0.24, 0.30, 0.30, 0.46, 0.48, 0.52, 0.72, 0.82 mg/kg. Based on the combined dataset considered by the 2013 JMPR the OECD MRL calculator recommends an MRL of 1.5 mg/kg (n = 25, STMR = 0.27 mg/kg).

The available diquat residues data supports continued use in canola. Based on the overseas rape seed data an MRL of 2 mg/kg is supported for diquat on SO 0495 Rape seed [canola] in conjunction with a 7 day harvest withholding period. This MRL would be in closer alignment to those established by Codex, Japan and Korea (compared to the current MRL for oilseeds at 5 mg/kg), reducing the potential risk to trade.

In response to the initial consultation Syngenta submitted additional overseas residue data for canola, to provide further support for these uses including in relation to trade.

Two GLP trials conducted in Europe involved pre-emergent application with residues <0.01 mg/kg after application at 971 – 1004 g ac/ha.

In North American trials involving application at 552 – 579 g ac/ha targeted at 7 days before harvest, residues were 0.020, 0.031, 0.051, 0.13, 0.18, 0.19, 0.27, 0.34, 0.38, 0.46, 0.46 and 0.77 mg/kg. The OECD MRL calculator recommends an MRL of 1.5 mg/kg (n = 12, STMR = 0.23 mg/kg) for this new dataset, which is the same as recommended previously.

The recommended MRL is:

- SO 0495 Rape seed [canola] 2 mg/kg

The supported harvest withholding period for canola is 7 days.

5.4.6.7 Poppies

The maximum Australian label rate for use on poppies is for a pre-harvest desiccation application at 0.8 kg ac/ha in conjunction with a 2 day withholding period.

Two overseas trials were submitted but were not considered to be reliable (Kennedy, 1985(b); Massey, 1987(f)). Two Australian studies detailing 6 trials were considered (Haller and Winner, 2013; Udy, 2011). No diquat residues ≥ LOQ (0.01 mg/kg) were found in any poppy seed sample from the 4 Tasmanian trials at any sampling period (zero, 2, 7 or 10 days after application at 0.8 kg ac/ha). No diquat residues ≥ LOQ (0.02 mg/kg) were found in any poppy seed sample from either Tasmanian trial at any sampling period (zero, 5, 10 and 15 days after application at 0.8 kg ac/ha).

The current MRL of *0.01 mg/kg for diquat on poppy seed remains appropriate.

The available diquat residues data supports continued use in poppies. The supported MRL is:

- SO 0698 Poppy seed *0.01 mg/kg

The 2 day harvest withholding period for poppies is supported.

5.4.7 Sugarcane

The available diquat residue trial on sugarcane is summarised below (McKenna, 1966).

Diquat may be used over the top of plant or ratoon cane at up to 0.23 kg ac/ha with no withholding period specified. There is a pre-harvest desiccation use at up to 0.6 kg ac/ha in conjunction with a 4 day withholding period. There is also a use as an aid in establishing sugarcane or in a fallow prior to sugarcane at up to 0.368 kg ac/ha. The current Australian MRL is Sugarcane at *0.05 mg/kg.

A single summary of a trial conducted on sugarcane was submitted. No detectable residues (LOQ 0.01 mg/kg) occurred in juice from sugarcane sampled 6 months after application of 1.12–2.24 kg ac/ha diquat, which was applied to act as a desiccant preventing flowering. The submitted information does not reflect any current Australian GAP or address the raw agricultural commodity (sugarcane billets).

As residue data are not available to support the over the top use or pre-harvest desiccation of sugarcane these uses are no longer supported .

Noting the results of the pre-emergent trials on rice and maize where residues were <0.05 mg/kg, the sugarcane MRL at *0.05 mg/kg can remain in place to support the use of diquat as an aid in establishing sugarcane or controlling weeds in a fallow prior to sugarcane. The supported withholding period for the supported pre-emergent use on sugarcane is 'Not required when used as directed'.

5.4.8 Hops

The available diquat residue trials on hops are detailed are summarised below (Simon, 1978). The maximum label use rate is 0.28 kg ac/ha as a directed inter-row spray prior to crop emergence from winter dormancy. The current Australian MRL is Hops, dry at 0.2 mg/kg.

Residue data for diquat on hops were provided for permit 13260 (which includes paraquat). Residues of diquat in hops were <0.05 mg/kg (n = 2) at 12-14 days after the last of 2–3 applications at 368 g ac/ha by inter row boom spray.

The available diquat residues data supports continued use in hops. The recommended MRL is:

- DH 1100 Hops, dry *0.05 mg/kg

The recommended harvest withholding period is 'Not required when used as directed' for this use as a directed inter row spray prior to crop emerging from winter dormancy.

5.4.9 Processed commodities

Studies were submitted that determined the residues of diquat in products from the processing of wheat, barley, sorghum and oilseed crops. Diquat residues in wheat, barley and sorghum grain were concentrated in the bran (Calderbank and Springett, 1971; Fujie, 1988(c)). In wheat, residues were found to concentrate generally 2-fold and in sorghum were found to concentrate on average four-fold from a dry milling process. The residue levels found in wholemeal flour and bread were similar to the levels found in the grain. It is noted that use on sorghum has not been supported. For wheat, processing factors for bran were 1.3× and 2.4×. Applying these processing factors to the HR in wheat grain of 0.78 mg/kg from the desiccation use gives residues of 1.0 and 1.9 mg/kg, both below the supported wheat MRL of 2 mg/kg. A separate MRL for wheat bran is not required, noting also that wheat will be bulked and blended at processing.

The levels of residues in beer were found to be 2–3% of those found in the barley whole grain from which it was prepared.

In studies of oilseeds such as rapeseed (McKenna, 1966; Anon., no date(c); Anon., 1972; Anon., 1980(a); Swaine, 1981(b); Kennedy, 1984(c); Kennedy, 1988(b)), sunflower (Anon., no date(c); Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1970(c); Anon., 1972; Anderson et al, 1995(c); Anderson and Renard 1995(b) and linseed (Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1972; Earl and Anderson, 1989(b); Anderson and Elsworth, 1994; Anderson and Moons, 1995; Anderson and Renard, 1995(a)) the diquat residue is concentrated in the cake and there are no detectable residues in the oil. In an additional European rape seed processing study conducted at 2 sites and evaluated by the JMPR (2013) residues in refined oil were <0.01 mg/kg and processing factors for solvent extracted meal ranged from 0.17–0.76×.

All but one of the submitted soybean studies, where beans, meal, and oil were measured, had no detectable residues of diquat in any of these fractions. In one soybean study residues were 0.07 mg/kg in the cake and not detectable in the oil. In this study the residues in the seed were not measured. The JMPR (1994) reviewed a soybean processing study and found there was a 2.6-fold concentration of diquat residues in the hulls of treated plants. There was no concentration in any other fraction and no residues were detectable in the crude or refined oil.

The MRL of 1 mg/kg for diquat on OC 0172 Vegetable oils, crude can be replaced with an MRL of *0.01 mg/kg for OR 0172 Vegetable oil, edible as the processing studies indicate that residues are not expected to occur in oil.

The recommended MRL is:

- OR 0172 Vegetable oil, edible *0.01 mg/kg

5.4.10 Use in aquatic areas

Diquat may be used to control weeds in aquatic areas with the following restraint:

> **Do not use treated water for human consumption, livestock watering or irrigation purposes for 10 days after application.**

A WHO evaluation concluded that when diquat is added to surface waters to control aquatic weeds, residues in the water rapidly decline, owing mainly to the absorption of diquat into the aquatic plants, where it is firmly bound until the decaying weeds disintegrate into the bottom mud. The diquat is then irreversibly bound to the soil particles, leaving the water free of diquat residues. Half-lives of diquat in natural waters are generally less than 48 h (JMPR, 1994).

Use of diquat in aquatic areas with the 10 day restraint on using water for human consumption, livestock watering or irrigation purposes continues to be supported from a residues and trade perspective.

5.5 Residues in animal feeds

The only entries for diquat in Table 4 of the current MRL Standard are ‘Legume Animal Feeds’ at 100 mg/kg and ‘Oilseed forage and fodder’ at 30 mg/kg. The Australian use pattern specifies rates of 0.28–0.37 kg ac/ha for grass, clover, medic and lucerne pasture and up to 0.6 kg ac/ha for clover and lucerne seed crops and legume crops that may be grazed or cut for feed. There is no grazing restraint for cereal crop forage or fodder, and it considered that these materials can be grazed after applications up to 0.6 kg ac/ha.

Studies were submitted that included residues trials with applications to pasture, including grass and mixed pasture, and legume based pasture. Trials were also conducted on cereals and legume crops where in almost all cases only the dried plant material at harvest after desiccation was sampled. (Anon., no date(b,d,e); Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Cardinali et al, 1967; Anon., 1972; Anon., 1973; Swaine and Hayward, 1982; Anon., 1987; Massey, 1987(d); Dick et al, 1995(e)).

5.5.1 Animal feed derived from grasses (including cereals)

The levels of diquat residues in trials conducted on grass resembled those results found in legumes. In trials conducted during 1964–65 in the UK mean diquat residues in grass were 26 and 13 mg/kg, one and 2 days, respectively, after an application of 0.3 kg ac/ha and 43 and 25 mg/kg, one and 2 days, respectively, after an application of 0.6 kg ac/ha. A trial on tall fescue conducted in the UK had residues ranging from 0.52 to 3.6 mg/kg one to 2 days after applications of 0.24–0.42 kg ac/ha. In a trial conducted on tall fescue in Australia residues after one day ranged from 0.77 to 27 mg/kg after an application of 0.5 kg ac/ha.

Detectable residues of diquat occurred in cereal grain straw. Residues were generally higher in oats and barley and for all winter cereals ranged from 2.5 to 26 mg/kg from pre-harvest desiccation applications at the maximum Australian use rate of 0.6 kg ac/ha. Residues in maize were much lower and generally not detectable due the application timing (pre-sowing or prior to emergence), which is consistent with the maize Australian GAP. However, application to sorghum can be as a pre-harvest desiccant and trials on sorghum with residues measured in forage or straw were not submitted. Residues of up to 11 mg/kg occurred in rice straw from pre-harvest desiccation applications of 0.6 kg ac/ha.

Additional Australian data for barley, oat and wheat straw were considered by the JMPR (2018) and have been provided to the APVMA separately. Residues of diquat 2–4 days after a pre-harvest application at 0.6 kg ac/ha were 0.27, 1.2, 1.8, 2.0, 2.4, 2.8 (3), 3.1, 3.3, 4.3, 5.6, 6.1, 6.2, 6.9, 23 and 26 mg/kg (dry weight).

Residues in animal feed derived from grasses are not covered by an existing Australian MRL. It is not clear if all the residue results for grass were reported on a fresh or dry weight basis, with exception of the JMPR cereal trials, which were expressed on a dry weight basis. However, samples of cereal straw from the trials involving pre-harvest desiccation applications should have a high dry matter content. The available data for grass and cereal forage and fodder suggests that residues should be below 100 mg/kg, the level at which the current legume animal feed MRL is set noting that the levels of diquat residues in trials conducted on grasses and cereals were similar to those results found in legumes (see below).

5.5.2 Animal feed derived from legumes

Studies submitted on lucerne, clover and medic (zero to 133 day PHI), including several that addressed a zero or one day PHI, generally had diquat residues between 20 and 40 mg/kg in the desiccated plant material, although 2 results were below 0.1 mg/kg, from applications approximating the Australian maximum use rate of 0.6 kg ac/ha and a PHI of 2–4 days. The HR at one day was 66.7 mg/kg in clover after 0.56 kg ac/ha (scaling not required). At longer PHIs the HR was 92.5 mg/kg (dry weight) in white clover at 4 days after 1.12 kg ac/ha (49.6 mg/kg scaled for rate).

Diquat residues in pea and bean haulms varied widely with a maximum residue recorded of 53 mg/kg. The trial information indicates all the samples were taken as dried material at harvest, including the samples in trials conducted as post-emergence weed control applications (Anon., no date(f); Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1972; Edwards, 1977; Anon., 1980(a); Culoto and de Mallmann, 1982; Swaine, 1983(a); Culoto, 1985(a,b); Kennedy, 1985(a); Kennedy, 1986(b); Massey, 1987(d);

Anon., 1987; Anderson, 1990; Dodsworth, 1990; Earl, 1991(a); Earl and Hall, 1994; Roper, 1995(a,b); Dick et al., 1995(c,d); Roper, 1996).

Residues of diquat in desiccated fodder of lentils and field peas were generally higher than those recorded in peas and beans haulms, with a mean residue of 40 mg/kg, although in all cases residues were <100 mg/kg, particularly at use rates of 0.50–0.55 kg ac/ha (the HR was 90 mg/kg after application at 1.1 kg ac/ha, or 40.1 mg/kg when scaled for application rate).

Residues in soybean stalks, stems, straw or fodder were in the range <0.05 to 20 mg/kg at PHIs of 3–119 days after application at 0.28–1.12 kg ac/ha.

In 8 European GLP dry bean trials provided by Syngenta in response to the initial consultation, residues in straw at 3-5 days after application at 600 g ac/ha were 1.6, 1.7, 3.1, 3.8, 4.7, 6.2, 6.7 and 10.0 mg/kg (as received), all well within the previously supported MRL of 100 mg/kg for Legume animal feeds, noting the straw should have a low moisture content after the desiccation treatment.

In the submitted trials residues in animal feed derived from legumes were below the current Australian MRL at 100 mg/kg, which remains appropriate.

5.5.3 Animal feeds derived from oilseeds

Limited data on feeds derived from oilseed plant material were provided to the review. Diquat residues in the stalks of linseed and sesame were <0.05 to 0.68 mg/kg at 12–98 days after application at 0.07–1.12 kg ac/ha (Anon., no date(g); Calderbank and Yuan, 1963; Calderbank and McKenna, 1964; McKenna, 1966; Anon., 1972; Earl and Anderson, 1989(b); Anderson and Elsworth, 1994; Anderson and Moons, 1995; Anderson and Renard, 1995(a,b). The current oilseed forage and fodder MRL at 30 mg/kg was established based on data for rape seed forage from the 2013 JMPR. Diquat residues in rape forage after a single application at a nominal rate of 600 g ac/ha at one day PHI (or later if higher residues were observed), in rank order were: 0.4, 1.7, 3.2, 3.5, 7.5, 8.1, 11 and 17 mg/kg (n=8). (assume DW as this was a pre-harvest desiccation use with application at BBCH 87-89). The Oilseed forage and fodder MRL is expected to remain appropriate for currently registered uses in conjunction with a one day grazing withholding period.

As noted by Syngenta in their response to the initial consultation, cotton trash is not used as an animal feed due to unacceptable residue risks from multiple pesticides currently used in cotton. This is normally managed by a label statement prohibiting the feeding of cotton trash to animals, which is considered cotton industry best practice. The restraint of 'DO NOT feed cotton fodder, stubble or trash to livestock' is recommended for the supported cotton use at crop establishment.

5.5.4 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 diquat in pastures, hay and fodder. Such animal feeds include citrus pulp, grape pomace, apple pomace, tomato pomace and almond hulls 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.

5.5.5 Conclusion on residues in animal feeds

The use of diquat on crops or situations which produce animal feeds continues to be supported. The one day grazing withholding period on current labels remains appropriate (noting that products formulated with paraquat have a 7 day grazing withholding period for horses).

The recommended grazing withholding period statement in relation to diquat is:

- DO NOT graze or cut for stock food for one day after application.

The recommended MRLs for animal feeds are summarised in Table 13.

Table 13: Recommended MRLs for animal feeds

Code	Animal feed commodity	Current MRL	Recommended MRL
AL 0157	Legume animal feeds	100	100
	Oilseed forage and fodder	30	30
AF 0161	Forage of cereal grains and other grass-like plants	–	100
AS 0161	Straw and fodder (dry) and hay of cereal grains and other grass like plants	–	100

5.6 Animal transfer studies and animal commodity MRLs

5.6.1 Poultry

Four studies on diquat residues in poultry were submitted and assessed. In 2 related studies, 3 groups of 30 chickens each were fed nominally 1, 5 or 10 mg/kg diquat in the diet for 28 days (Fletcher, 1977; Lai et al, 1977). Ten chickens from each group were sacrificed on day 21 and day 28 with the remaining birds kept on a control diet for 7 days prior to sacrifice. Eggs were collected on days one, 14, 21 and 28 and the final day of the recovery diet. No residues greater than 0.005 mg/kg were detected in the egg, fat, muscle, liver or heart samples. In skin, only the day 21 sample from the 10 mg/kg dose contained residues greater than 0.005 mg/kg at 0.006 mg/kg. The gizzards contained detectable residues which ranged from 0.006 mg/kg at the lowest feeding level at day 21 to 0.022 mg/kg at the highest level at day 28. Residues in gizzards declined after cessation of feeding.

In 2 further studies, 3 groups of 40 hens each were fed nominally 2, 5 or 10 mg/kg diquat in the diet for 6 weeks (Leahey, 1975; Edwards and Smith, 1975). Samples of eggs were collected throughout the trial and tissue samples taken after 6 weeks. No detectable residues of diquat were found in the egg white or yolk, and from hens slaughtered after 16, 28 and 45 days, no detectable residues of diquat were found in the meat, liver or kidneys. The limit of detection in eggs, meat and liver was 0.05 mg/kg and in kidney was 0.2 mg/kg.

Current poultry MRLs are *0.01 mg/kg for eggs and *0.05 mg/kg for meat and offal. Data from the animal transfer studies indicate that a dietary intake of 10 mg/kg would not produce detectable residues in the meat, offal or eggs. Although not a typical diet, it is assumed either cereal grain or pulses could make up 100% of the poultry diet. In this case, the poultry dietary intake at the current maximum MRLs for cereals and pulses (5 and 1 mg/kg, respectively) would not result in violative residues in the meat, offal or eggs.

More refined dietary burden calculations for poultry broilers and layers are presented in Table 14 and Table 15 using the OECD Feed Calculator and the relevant HR or Supervised Trials Median Residue (STMR).

Table 14: Calculation of poultry broiler dietary burden of diquat

Poultry broiler – for MRLs							
Commodity	**Codex Commodity Code** [13]	**Residue (mg/kg)**	**Basis**	**Dry matter (%)**	**Residue dry weight (mg/kg)**	**Diet content (%)**	**Residue contribution (ppm)**
Alfalfa forage	AL	100	HR	100	100.0	–	–
Rice grain	VD	2.1	STMR	88	2.4	50	1.2
Sorghum, grain	GC	1.1	STMR	86	4.3	50	0.6
Barley grain	GC	1.1	STMR	88	1.3	–	–
Corn, field grain	GC	0.05	STMR	88	0.01	–	–
Total						**100**	**1.8**

Table 15: Calculation of poultry broiler dietary burden of diquat

Poultry broiler – for MRLs							
Commodity	**Codex Commodity Code**	**Residue (mg/kg)**	**Basis**	**Dry matter (%)**	**Residue dry weight (mg/kg)**	**Diet content (%)**	**Residue contribution (ppm)**
Barley straw	AF/AS	26	HR	100	26	–	–
Rape forage	AM/AV	17	HR	100	17	–	–
Rice grain	GC	2.1	STMR	88	2.4	50	1.2

[13] See crop groups, available on the APVMA website.

Poultry broiler – for MRLs							
Commodity	Codex Commodity Code	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue contribution (ppm)
Sorghum, grain	GC	1.1	STMR	86	1.3	50	0.6
Barley grain	GC	1.1	STMR	88	1.3	–	–
Corn, field grain	GC	0.05	STMR	88	1.1	–	–
Total						**100**	**1.8**

As diquat residues above the LOQ of 0.01 mg/kg for eggs and 0.05 mg/kg for meat and offal were not observed in the feeding study conducted at a feeding level of 10 ppm, finite residues are not expected from the feeding level associated with current uses (1.8 ppm). The current poultry commodity MRLs remain appropriate.

5.6.2 Ruminants

Several studies in ruminants were submitted and assessed. In one study, 12 Friesian cows were fed for 30 days with diets including pelleted grass nuts containing nominally zero, 20, 50 or 100 mg diquat/kg diet dry weight (Edward et al, 1976). The grass nuts were prepared from grass sprayed with diquat at a rate of 4 kg ac/ha and cut after 4 days. The cut grass was pelleted and stored at ambient temperature for up to 2 years. Residues in the grass immediately after treatment were 940 mg/kg dry weight, in the nuts after pelleting were 212 mg/kg dry weight, and a mean of 209 mg/kg in the nuts during the feeding study. Milk was collected and analysed 3 times per week, and after 30 days 2 animals from each treatment group were slaughtered and tissues analysed. The remaining animal from each group was maintained on a control diet for 7 days then slaughtered. No residues of diquat above 0.001 mg/kg were detected in the milk and no residues >0.01 mg/kg were detected in tissues (liver, kidney, fat and muscle).

In another study, a single cow was dosed orally with 10 grams diquat and milk collected at 0, 24, 48, 72 and 96 hours for analysis (Daniel, 1962). The dose administered is equivalent to 1,000 mg/kg diquat in the diet. No detectable residues of diquat were found (the limit of detection was 0.01 mg/kg).

In another study, 3 groups of 5 cows were fed either rapeseed cake containing 50 mg/kg diquat, sunflower cake containing 55 mg/kg diquat, or rapeseed cake from the field containing 0.45 mg/kg diquat, for a period of 31 days (Sipos, 1973). Samples of milk were taken daily and analysed throughout the feeding period and no detectable residues of diquat were found (residues were <0.005 mg/kg). No detectable residues of diquat were found in the tissues (liver, kidney, kidney fat, heart, brain, bone marrow, stomach or meat) of sacrificed cows at the conclusion of the feeding period. The limit if detection was 0.01 mg/kg for the kidney, kidney fat, heart and meat, 0.02 mg/kg for the liver and stomach, 0.02–0.025 mg/kg for the brain, and 0.03 mg/kg for the bone marrow.

In a study involving cattle and sheep 6 acres of Italian ryegrass was sprayed with diquat at a rate of approximately 0.3kg ac/ha (Black et al, 1966). The crop was harvested 4 days later, and a silo filled with about 50 tonnes of herbage. After 5 months samples of silage were analysed for diquat residues, and a mean value of 3.6 mg/kg dry weight was obtained. A Hereford steer was sacrificed after being fed a daily ration incorporating 18–23 kg of silage for one month, and no diquat residues were detected (residues were <0.01 mg/kg) in the meat and organs. A Dairy Shorthorn fed the same ration had milk collected and analysed on alternate days for a period of 2 weeks, 2 weeks after commencement of feeding, and similarly, no residues of diquat were detected (residues were <0.003 mg/kg).

Twenty sheep in the same study (Black et al, 1966) were fed silage (mixed grass/clover) containing diquat residues of either 6.6 or 13.3 mg/kg (dry) for a period of 8 days. The concentration of diquat in the urine and faeces was determined over a 3 day period. The amount of diquat excreted in the faeces was 40–50% of the intake and <10% in the urine. No detectable residues of diquat (residues were <0.01 mg/kg) were found in samples of brain, liver and kidneys.

In an additional experiment, Black et al, (1966) incubated diquat with rumen liquor or faeces. In faeces, a 35% loss was reported after 2 days but no further loss on prolonged incubation. There was little degradation of diquat in the rumen liquor after incubation for 10 hours but thereafter there was ‘an appreciable loss’, although this was not quantified.

Cardinali et al (1967) applied diquat as a pre-harvest desiccant to lucerne at a rate of 1.12 kg ac/ha. Samples of hay were analysed 9 days later and found to have diquat residues of 19.3 mg/kg (wet), 23.12 mg/kg (dry). A cow was fed treated hay for 29 days (consuming a total of 7.163 grams of diquat). Milk taken and analysed after 8 days or after 29 days did not have detectable residues of diquat (residues were <0.01 mg/kg). Samples of meat and liver also had no detectable residues of diquat (residues were <0.01 mg/kg). Sheep fed the treated hay for 29 days (consuming a total of 427 mg of diquat) did not have detectable residues in samples (residues were <0.01 mg/kg) of flesh and liver.

Two lactating cows were fed 5 kg each of ground sunflower seed daily, containing 0.2 mg/kg diquat, for 185 days (Lembinski et al, 1972). The total amount of diquat consumed during the feeding period was 185 and 225 mg. Samples of milk, urine and faeces were collected at intervals during the feeding period, and the calf of one cow was slaughtered 7 days after birth. There were no detectable residues of diquat in any of the samples of milk, faeces or urine analysed, or in the liver and kidneys of the calf. Three one year old wethers were fed 0.5 kg of ground sunflower seed daily, containing 0.2 mg/kg diquat, for 141 days. The total quantity consumed was about 14.1 mg diquat. There were no detectable residues of diquat in the livers or kidneys of the wethers at the end of the feeding period. The limits of detection were 0.01 mg/kg for milk and urine, and 0.03 mg/kg for faeces, liver and kidneys.

Diquat dietary burdens calculations for beef and dairy cattle are presented in Table 16 and Table 17 using the OECD livestock feed calculator using relevant HR or STMR. Residues in legume animal feeds and pastures are assumed to be at the MRL as a worst case, rather than the HR.

Table 16: Calculation of beef cattle dietary burden of diquat

Beef cattle – for MRLs							
Commodity	Codex Commodity Code[14]	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue contribution (ppm)
Alfalfa forage	AL	100	HR	100	100.0	100	100.0
Barley straw	AF/AS	26	HR	100	26.0	–	–
Rice grain	GC	2.1	STMR	88	2.4	–	–
Sorghum, grain	GC	1.1	STMR	86	1.3	–	–
Barley grain	GC	1.1	STMR	88	1.3	–	–
Potato culls	VR	0.2	HR	20	1.0	–	–
Corn, field grain	GC	0.05	STMR	88	0.1	–	–
Total						**100**	**100**

Table 17: Calculation of dairy cattle dietary burden of diquat

Dairy cattle – for MRLs							
Commodity	Codex Commodity Code[15]	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue contribution (ppm)
Alfalfa forage	AL	100	HR	100	100.0	100	100
Bean vines	AL	100	HR	100	100.0	40	40.0
Barley straw	AF/AS	26	HR	100	26.0	–	–

[14] See crop groups, available on the APVMA website.

[15] See crop groups, available on the APVMA website.

Dairy cattle – for MRLs							
Commodity	Codex Commodity Code [15]	Residue (mg/kg)	Basis	Dry matter (%)	Residue dry weight (mg/kg)	Diet content (%)	Residue contribution (ppm)
Oat straw	AF/AS	26	HR	100	26.0	–	–
Rape straw	AM/AV	17	HR	100	17	–	–
Rice grain	GC	2.1	STMR	88	2.4	–	–
Sorghum, grain	GC	1.1	STMR	86	1.3	–	–
Barley grain	GC	1.1	STMR	88	1.3	–	–
Corn, field grain	GC	0.05	STMR	88	0.1	–	–
Total						**100**	**100**

5.6.3 Required animal commodity MRLs

Current MRLs are *0.05 mg/kg for meat (mammalian) and edible offal (mammalian) and *0.01 mg/kg for milks. Data from the animal transfer studies indicate that a dietary intake of 100 ppm would not produce detectable residues in the meat or offal and a dietary intake of 1,000 ppm would not produce detectable residues in the milk. The submitted residues studies support the current Table 4 entries of 100 mg/kg for Legume Animal Feeds and 30 mg/kg for Oilseed forage and fodder or a new entry to account for residues in grass pasture or cereal forage and fodder of 100 mg/kg. Therefore, finite residues in meat, offal and milks are not expected to occur based on the current maximum dietary intake for ruminants and pigs. The current mammalian commodity MRLs remain appropriate.

5.7 Crop rotation

In a confined accumulation study radiolabelled diquat was applied to soil at 1.5x the maximum Australian use rate and seeds of carrots, lettuce and wheat were planted 30, 120 and 365 days after treatment and grown to maturity. Detectable residues only occurred in the carrot leaf and wheat straw samples but were attributed to soil contamination (Lee, 1989).

Additional studies were conducted where small plots of carrot, lettuce and wheat at a site in Florida (Fujie, 1989(a)), and small plots of carrot, lettuce and oats at a site in California (Fujie, 1989(b)) were irrigated at approximately ¼, ½, ¾ and maturity with water containing diquat at a nominal concentration of 0.1 mg/L. Crops were sampled one day prior to the first irrigation and at maturity one day after the last irrigation, except for wheat and oats, which were allowed to dry in the field prior to harvesting as per normal agricultural practice. No diquat residues were detected in any of the crop samples analysed.

The conclusion that diquat residues are not expected in rotational crops from the Australian use patterns is in line with the JMPR (2013) evaluation which concluded that crops grown in rotation with diquat-treated crops are not expected to contain residues of diquat. Diquat residues in soil should contribute little to residue levels in rotational crops.

5.8 Spray drift for livestock areas

Data from the animal transfer studies indicate that a dietary intake of 100 ppm would not produce detectable residues in the meat or offal of animals grazing treated areas or fed a diet containing treated plant material. The Regulatory Acceptable Level for calculation of no spray downwind buffer zones for the protection of international trade will be taken as 100 ppm.

5.9 Dietary risk assessment

5.9.1 Chronic dietary exposure assessment

The chronic dietary exposure to diquat 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 diquat is equivalent to <30% of the ADI.

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

5.9.2 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 <10% of the ARfD. It is concluded that the acute dietary exposure is acceptable.

5.10 Residue related aspects of trade

The overseas MRLs presented in Table 18 are established for commodities considered to be major export commodities.

Table 18: International MRLs for Australian major export commodities (December 2023)

Commodity	Australia	Codex [16]	EU [17]	Japan [18]	Korea [19]	Taiwan [20]	USA [21]
Residue definition	Diquat cation	Diquat ion	Diquat	Diquat ion	–	–	Calculated as the cation
Barley	5 (current)	5	*0.02	5	–	–	0.02 (cereal grain)
Oats	5 (current) 2 (proposed)	–	2	2 (other cereal grains)	–	–	0.02 (cereal grain
Wheat	2 (current)	–	*0.02	0.1	–	–	0.02 (cereal grain
Maize	*0.05 (proposed) 0.1 (current)	–	*0.02	0.02	–	–	0.02 (cereal grain
Rye	2 (current)	1.5	*0.02	2	–	–	–
Sorghum	2 (current) Proposed *0.05 after a	–	*0.02	–	–	–	–

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

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

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

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

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

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

Commodity	Australia	Codex [16]	EU [17]	Japan [18]	Korea [19]	Taiwan [20]	USA [21]
	phase out period						
Rice	5 (current) Proposed *0.05 after a phase out period	–	*0.02	0.03 (brown rice)	–	–	0.02 (cereal grain
Rice, polished	1 (current) Proposed for deletion after a phase out period	–	–	–	–	–	0.02 (cereal grain
Cotton seed	Cotton seed proposed for deletion after a phase out period	–	*0.01 (cotton seed)	–	–	–	0.2 (cotton seed)
Rape seed [canola]	2 (proposed for rape seed)	1.5 (rape seed)	1.5 rapeseeds/canola seeds)	2 (rapeseeds)	–1.5 (rape seed)	–	2 (canola seed)
Pulses	1 (current)	0.4 (dry beans subgroup) 0.9 (dry peas subgroup, Chick-pea (dry))	0.2 (beans) 0.2 (lentils) 0.3 (peas)	0.4 (soybeans, dried) 0.9 (beans, dried, Peas) 0.9 (other legumes pulses)	0.9 (lentil) 0.9 (pea) 0.3 (soybean)	-	0.05 (vegetable, seed and pod)
Sugar cane	*0.05 (current)	–	*0.01	0.02	–	–	0.2
Fruits	*0.05 (proposed for citrus) *0.01 (proposed for berries, pome fruit, stone fruit) *0.05 (current Fruits)	*0.02 (citrus fruits) *0.02 (pome fruits) *0.02 (stone fruits)	0.02 (citrus fruits) *0.01 (grapes) 0.02 (pome fruits) 0.02 (stone fruit)	0.02 (lemon) 0.02 (orange) 0.02 (grapefruit) 0.02 (lime) 0.02 (apple) 0.02 (pear) 0.02 (peach, nectarine, apricot, plum, cherry) 0.01 (grape)	–	–	0.05 (grape) 0.05 (citrus group 10) 0.02 (pome group 11) 0.02 (stone group 12)

Commodity	Australia	Codex [16]	EU [17]	Japan [18]	Korea [19]	Taiwan [20]	USA [21]
Edible offal (mammalian)	*0.05 (current)	*0.01	*0.05 (bovine)	0.01 (cattle liver) 0.01 (cattle kidney)	–	0.05	0.05 (cattle meat byproducts)
Meat [mammalian]	*0.05 (current)	*0.01	*0.05 (bovine)	0.01 (cattle muscle) 0.01 (cattle fat)	–	0.05	0.05 (cattle meat) 0.05 (cattle fat)
Milks	*0.01 (current)	*0.001	*0.01	0.001	–	0.01	0.02

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

It is noted that following the 2019 Codex Committee on Pesticide Residues (CCPR) the Codex MRL's for oats (2 mg/kg); wheat (2 mg/kg); wheat bran, unprocessed (2 mg/kg); wheat flour (0.5 mg/kg); and wheat wholemeal (2 mg/kg) were revoked. These MRLs were revoked following the 2018 JMPR assessment that concluded that a MRL could not be recommended as they did not have data that matched the critical GAP which was assessed by the JMPR.

The cereal use patterns have not changed, and no changes have been proposed to the barley, wheat and rye MRLs. The barley MRL is at the same levels as that established by Codex but, as noted, the Codex MRLs for oats and wheat (including processed fractions) were withdrawn in 2019. The Australian MRL for oats is proposed to be reduced to 2 mg/kg, which is the same as established in the EU and Japan, but higher than the USA. The maize MRL will be reduced to *0.05 mg/kg reflecting the supported use pattern at crop establishment. Although the supported MRLs for several cereal grains (with pre-harvest use) are higher than the standards in several markets this risk to trade has been managed in the past. It is noted that the pre-harvest uses on rice and sorghum are no longer supported.

Use on cotton will not be supported . A longer withholding period will be recommended for canola which will allow the diquat rapeseed MRL to be reduced to 2 mg/kg which is similar to those MRLs established by Codex and in most overseas markets (except Taiwan).

No changes have been proposed to the current diquat pulse MRL at 1 mg/kg which again is higher than the tolerances established overseas. As no changes have been proposed to current use patterns, this risk is also unchanged.

The current Fruits and sugar cane MRLs for diquat are both established at the LOQ for the analytical method. No changes are proposed to the sugar cane MRL. The fruits MRL will be expanded into the Codex fruit commodity groups at the relevant LOQ for each crop. The risk to trade in these commodities is low.

No changes have been recommended to the current animal commodity MRLs for diquat which are established at the LOQ for the analytical method. The risk to trade in commodities of animal origin is low.

Oaten hay is also a major export commodity, noting that an MRL of 100 mg/kg has been recommended for diquat on AS 0162 Hay and fodder of grasses (dry). Approximately 85% of exports are oaten hay, while 10% is straw and the balance is predominantly lucerne hay and chaff. Approximately 85% of Australian export hay is destined for Japan, while the volume of hay exported to China and the UAE is increasing. An animal feed MRL of 100 mg/kg has been established for diquat on grass in Japan [22] As before 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 diquat to assist industry to meet market requirements. The fodder industry also supported the MRL recommendations made as part of the review evaluation.

For cereal grains (barley, oats, rye, triticale and wheat), pulses, canola and oaten hay, finite residues of diquat are expected from the Australian uses which were supported by this residues and trade assessment. As the potential trade risk associated with diquat residues expected in cereal grains (barley, oats, rye, triticale and wheat), pulses, canola, and oaten hay have been managed by industry, and because international standards for diquat have not significantly changed in recent years (except for the removal of the Codex MRLs for wheat and oats in 2019), it is currently considered that the trade risk associated with the uses of diquat in cereal grains, pulses, canola 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 cereals (barley, oats, rye, triticale and wheat), pulses, canola:

> **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 sampling data which demonstrates a high degree of export compliance with importing countries diquat MRLs for cereals, pulses and oilseeds. Noting also the additional data provided to confirm the previously recommended MRLs, the risk to trade in cereals, pulses and oilseeds is not considered to be undue.

5.11 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.

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

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 and 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 garden uses' noting also the following recommendations for uses which are not supported.

- Use on pineapple is not supported in the absence of specific residue data.
- For bulb vegetables, use is only supported for the bulb onions subgroup as residue data for green onions, which may have a higher residue potential, were not available.
- For brassica vegetables use is only supported for the crops with specific residue data, i.e. broccoli, head cabbages, cauliflower and Chinese cabbage (type Pe-tsai).
- Use on fruiting vegetables, cucurbits, is supported for cucumber only in the absence of specific residue data for other commodities in this group.
- Use on stalk and stem vegetables is supported for asparagus only (prior to spear emergence) in the absence of reliable residue data for other commodities in this group.
- Use on herbs and spices is not supported in the absence of specific residue data.

5.11.1 Other uses that are no longer supported from a residues perspective

- There was insufficient reliable data for sorghum to confirm the current MRL for pre-harvest desiccation uses and assess dietary risk. Pre-harvest desiccation use on sorghum is no longer supported. Use at crop establishment continues to be supported for sorghum from a residues perspective.
- There was insufficient reliable data for rice to confirm the current MRLs for pre-harvest desiccation uses and assess dietary risk. Pre-harvest desiccation use on rice is no longer supported. The pre-emergent use on rice is however supported from a residues perspective.
- There is insufficient residue data to support the registered use on cotton which is no longer supported (use at crop establishment continues to be supported).
- As residue data are not available to support the over the top use or pre-harvest desiccation of sugarcane these uses are no longer supported. The pre-emergent use on sugar cane is however supported from a residues perspective.

5.11.2 Winter cereals

Labels with the winter cereal use pattern should specify the crops as barley, oats, rye, triticale and wheat. The broad term of winter cereals should be removed from product labels as it does not align with the APVMA crop group guidance.

5.11.3 Supported withholding periods

- The supported harvest withholding period for orchards and row crops for pre-emergent applications or applications by a shielded spray is 'Not required when used as directed'.
- The supported harvest withholding periods for the pre-harvest desiccation of potatoes and sweet potatoes are 7 and 14 days respectively.
- The supported harvest withholding period for pre-harvest desiccation of all pulse crops with this use (dry beans, dry peas, lentils, chickpeas, faba beans, lupins, mung beans, pigeon peas and soya beans) is 4 days.
- The supported harvest withholding period for barley, oats, rye, triticale and wheat for pre-harvest weed control is 4 days.
- The supported harvest withholding period for maize is 'Not required when used as directed'.
- The supported harvest withholding period for rice for the supported pre-emergent use pattern is 'Not required when used as directed'.
- The supported harvest withholding period for canola, linseed and sunflower is 7 days.
- The supported harvest withholding period for poppies is 2 days.
- The supported harvest withholding period for establishing sugarcane or controlling weeds in a fallow prior to sugarcane is 'Not required when used as directed'.
- The supported harvest withholding period for hops is 'Not required when used as directed'.
- The supported withholding period for crop establishment uses (canola, chickpeas, cereals (wheat, barley, oats, rye, triticale, sorghum, maize, millet), cotton, field beans, field peas, lentils, linseed, lupins, fodder rape, mung beans, navy beans, peanuts, pigeon peas, safflower, soybeans, sunflower, pasture (clover, grass, lucerne, medic), vetch) is 'Not required when used as directed'.
- The supported grazing withholding period statement in relation to diquat is:
  - DO NOT graze or cut for stock food for one day after application.

  (noting that diquat products that also contain paraquat require a 7 day grazing withholding period for horses).
- For the supported use on cotton at crop establishment the following grazing restraint is recommended: 'DO NOT feed cotton fodder, stubble or trash to livestock'.

5.11.4 Aquatic areas

Use of diquat in aquatic areas with the 10 day restraint on using water for human consumption, livestock watering or irrigation purposes continues to be supported.

5.11.5 Spray drift

The livestock area RAL is 100 ppm. Mandatory no-spray zones for protection of international trade are not required for either ground or aerial application based on this RAL. This assessment was based on a droplet size of fine.

5.11.6 Trade

For cereal grains (barley, oats, rye, triticale and wheat), pulses, canola and oaten hay, finite residues of diquat are expected from the Australian uses. As the potential trade risk associated with diquat residues expected in cereal grains (barley, oats, rye, triticale and wheat), pulses, canola and oaten hay, have been managed by industry, and because international standards for diquat have not significantly changed in recent years (except for the removal of the Codex MRLs for wheat and oats), it is currently considered that the trade risk associated with the uses of diquat in cereal grains (barley, oats, rye, triticale and wheat), pulses, canola 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 cereals (barley, oats, rye, triticale and wheat), pulses, canola:

> **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].**

As the Australian MRLs for cereal grains (barley, oats, rye, triticale and wheat), pulses, canola and oaten hay are higher than some of those set by Codex and major export destinations, the APVMA should seek comments from members of the grain and fodder industries on their ability to manage the risk to international trade associated with diquat during the Proposed Regulatory Decision consultation for diquat before a final decision against the trade criteria is made for pre-harvest uses on cereal grains other than maize, pulses, canola and oaten hay.

5.11.7 Required MRL changes

Table 19 and Table 20 show the changes required to the Agricultural and Veterinary Chemicals (MRL Standard for Residues of Chemical Products) Instrument 2023, based on the uses supported by the risk assessment outcomes in this Residues and Trade assessment of diquat. It should be noted that the outcome of other risk assessments conducted by the APVMA will be applied to determine which use patterns remain supported overall.

Table 19: Amendments to Table 1 of the MRL Standard

Code	Commodity	Current MRL	Recommended MRL
VS 0621	Asparagus	-	*0.05
FT 0026	Assorted tropical and sub-tropical fruits – edible peel	–	*0.1

Code	Commodity	Current MRL	Recommended MRL
FI 0030	Assorted tropical and sub-tropical fruits – inedible peel {except pineapple}	–	*0.02
GC 0640	Barley	5	5
VP 0061	Beans, except broad bean and soya bean	1	Delete
FB 0018	Berries and other small fruits	–	*0.05
VP 0522	Broad bean (green pods and immature seeds)	1	Delete
VB 0400	Broccoli	–	*0.02
VA 2031	Bulb onions	–	0.2
VB 0041	Cabbages, head	–	*0.02
VB 0404	Cauliflower	–	*0.02
VB 0467	Chinese cabbage (type Pe-tsai)	–	*0.02
FC 0001	Citrus fruits	–	*0.05
SO 0691	Cotton seed	–	T5 during phase out, *0.05 after phase out
VS 0424	Cucumber	-	0.1
MO 0105	Edible offal (Mammalian)	*0.05	*0.05
PE 0112	Eggs	*0.01	*0.01
VO 0050	Fruiting vegetables, other than cucurbits	–	*0.01
	Fruits	*0.05	Delete
DH 1100	Hops, dry	0.2	*0.05
VL 0053	Leafy vegetables	–	0.2
VP 0060	Legume vegetables	–	*0.05
SO 0693	Linseed	*0.01	5
GC 0645	Maize	0.1	*0.05
MM 0095	Meat [mammalian]	*0.05	*0.05
ML 0106	Milks	*0.01	*0.01

Code	Commodity	Current MRL	Recommended MRL
GC 0646	Millet	–	*0.05
GC 0647	Oats	5	2
SO 0088	Oilseed [except linseed and poppy seed]	5	Delete
SO 0305	Olives for oil production	–	*0.1
VA 0385	Onion, Bulb	0.1	Delete
SO 0697	Peanut	–	*0.05
VP 0063	Peas	0.1	Delete
FP 0009	Pome fruits	–	*0.01
SO 0698	Poppy seed	*0.01	*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	1
SO 0495	Rape seed [canola]	–	2
GC 0649	Rice	5	T5 during phase out, *0.05 after phase out
CM 1205	Rice, polished	1	Delete (T1 during phase out)
VR 0075	Root and tuber vegetables {except Potato; Sweet potato}	–	0.1
GC 0650	Rye	2	2
SO 0699	Safflower	–	*0.05
GC 0651	Sorghum	2	T2 during phase out, *0.05 after phase out
FS 0012	Stone fruits	–	*0.01
VR 0596	Sugar beet	0.1	Delete

Code	Commodity	Current MRL	Recommended MRL
GS 0659	Sugar cane	*0.05	*0.05
SO 0702	Sunflower seed	–	1
VR 0508	Sweet potato	–	0.2
TN 0085	Tree nuts	*0.05	*0.05
GC 0653	Triticale	2	2
	Vegetables [except beans; broad bean; lupin (dry); onion, bulb; peas; potato; soya bean (dry); sugar beet]	*0.05	Delete
OC 0172	Vegetable oils, crude	1	Delete
OR 0172	Vegetable oil, edible	–	*0.01
GC 0654	Wheat	2	2

Table 20: Amendments to Table 4 of the MRL Standard

Code	Animal feed commodity	Current MRL	Recommended MRL
AL 0157	Legume animal feeds	100	100
	Oilseed forage and fodder	30	30
AF 0161	Forage of cereal grains and other grass-like plants	–	100
AS 0161	Straw and fodder (dry) and hay of cereal grains and other grass like plants	–	100

5.12 Consideration of the combined risk assessments

The APVMA's risk assessments for environmental exposure to diquat based on currently approved uses indicate that many of those uses will not continue to be supported (See Appendix A). The uses that are supported by the combined APVMA risk assessment are presented in Table 21. These uses are within the application rate range indicated on currently approved labels.

Table 21: Diquat uses supported by human health, environment, and residues and trade risk assessments

Crop use or situation	Weeds controlled/ use	Application method	Assessment outcome
Hops	Annual broadleaf and grass weeds	Inter-row spray	Supported

Crop use or situation	Weeds controlled/ use	Application method	Assessment outcome
Lucerne	Capeweed and Erodium spp.	Boomspray	Supported up to 140 g ac/ha per season
Oilseed poppies	Pre-harvest desiccation	Boomspray	Supported up to 800 g ac/ha
Oil seed poppies	General weed control	Boomspray	Supported up to 283 g ac/ha per season
Pasture renovation and establishment	Capeweed (very young seedling, 2–3 leaf stage only)	Boomspray	Supported up to 188 g ac/ha per season
Row crops, vegetables and market gardens (berries and other small fruit (except grapes)	Broadleaf weeds	Boomspray, handwand, inter-row spray (shielded)	Supported up to 283 g ac/ha per season (noting crop group change required by residues)
Row crops, vegetables and market gardens (brassica vegetables: broccoli, head cabbages, cauliflower and Chinese cabbage (type Pe-tsai)	Broadleaf weeds	Boomspray, handwand inter-row spray (shielded)	Supported up to 283 g ac/ha per season (noting crop group change required by residues)
Row crops, vegetables and market gardens (bulb vegetables: bulb onions)	Broadleaf weeds	Boomspray, handwand, inter-row spray (shielded)	Supported up to 283 g ac/ha per season (noting crop group change required by residues)
Row crops, vegetables and market gardens(fruiting vegetables: other than cucurbits)	Broadleaf weeds	Boomspray, handwand, inter-row spray (shielded)	Supported up to 283 g ac/ha per season (noting crop group change required by residues)
Row crops, vegetables and market gardens (leafy vegetables)	Broadleaf weeds	Boomspray, handwand, inter-row spray (shielded)	Supported up to 283 g ac/ha per season (noting crop group change required by residues)
Row crops, vegetables and market gardens (legume vegetables)	Broadleaf weeds	Boomspray, handwand, inter-row spray (shielded)	Supported up to 283 g ac/ha per season (noting crop group change required by residues)
Row crops, vegetables and market gardens (root and tuber vegetables)	Broadleaf weeds	Boomspray, handwand, inter-row spray (shielded)	Supported up to 283 g ac/ha per season (noting crop group change required by residues)

Crop use or situation	Weeds controlled/ use	Application method	Assessment outcome
Wheat, oats (3–4 leaf to early tillering)	Capeweed (small seedlings)	Boomspray	Supported up to 122 g ac/ha per season

5.12.1 Cotton

While a pre-harvest crop desiccation use was supported for cotton by environment it was not supported by residues due to a lack of relevant data for cotton seed. At the end of the phase out period an MRL of *0.05 mg/kg will be established for SO 0088 Oilseed {except Poppy seed} to support the alternative use at crop establishment as new data for cotton and previously submitted data for other crops (rice, maize and peanuts) has indicated residues are not expected at harvest for this use. The appropriate harvest withholding period for this supported crop establishment use in cotton is "Not required when used as directed".

As noted in submissions to the public consultation, cotton trash is not used as an animal feed due to unacceptable residue risks from multiple pesticides currently used in cotton. This is normally managed by a label statement prohibiting the feeding of cotton trash to animals, which is considered cotton industry best practice. The restraint of 'DO NOT feed cotton fodder, stubble or trash to livestock' is recommended for the supported cotton use at crop establishment.

5.12.2 Hops (supported use: 0.28 kg ac/ha)

The use on hops is as a directed inter-row spray at 0.28 kg ac/ha to crop emerging from winter dormancy. The withholding period is 'Not required when used as directed'. The current Australian MRL is Hops, dry at 0.2 mg/kg.

Residue data for diquat on hops were provided. Residues of diquat in hops were <0.05 mg/kg (n = 2) at 12–14 days after the last of 2–3 applications at 0.368 kg ac/ha by inter row boom spray.

The available diquat residues data supports continued use in hops. The recommended MRL is:

- DH 1100 Hops, dry *0.05 mg/kg

The recommended harvest withholding period is 'Not required when used as directed' for this use as a directed inter row spray prior to crop emerging from winter dormancy. The recommended grazing withholding period for sprayed vegetation is one day.

5.12.3 Lucerne (supported use: 0.140 kg ac/ha)

The use on lucerne is for application at up to 0.140 kg ac/ha. Heavy grazing is necessary to reduce lucerne to 2 cm in height before spraying. The grazing withholding period is one day. The current entry for diquat in Table 4 of the MRL Standard is 'Legume Animal Feeds' at 100 mg/kg.

Studies submitted on lucerne, clover and medic (zero to 133 day PHI, with applications of 0.1 to 6 kg ac/ha), including several that addressed a zero or one day PHI, generally had diquat residues between 20 and 40 mg/kg in the desiccated plant material, from the approximate rate of 0.6 kg ac/ha and a PHI of 2–4 days. The HR at one day was 66.7 mg/kg in clover after 0.56 kg ac/ha (16.7 mg/kg scaled for the supported rate of 0.140 kg ac/ha). At longer PHIs the HR was 92.5 mg/kg (dry weight) in white clover at 4 days after 1.12 kg ac/ha (11.6 mg/kg scaled for rate, noting this is outside the normal scaling range).

In the submitted trials residues in animal feed derived from legumes were below the current Australian MRL for Legume animal feeds at 100 mg/kg. However, this MRL will be replaced with a Primary feed commodities MRL at 30 mg/kg to account for the lower supported rate for lucerne and cover other uses discussed below (see recommendations below for wheat and oats which showed similar residues in forage). The supported grazing withholding period is 1 day.

5.12.4 Oilseed poppies

This review has supported the preharvest desiccation of poppies (at up to 800 g ai/ha) and also application for general weed control (at up to 300 g ai/ha). The current MRL at the LOQ of *0.01 mg/kg for diquat on poppy seed was considered appropriate for the highest registered rate considered earlier based on Australian residue trial data showing residues were not found in seed. The MRL should therefore remain appropriate. The available diquat residues data supports continued use in poppies. The supported MRL is:

- SO 0698 Poppy seed *0.01 mg/kg

The supported harvest withholding period for poppies is 2 days.

5.12.5 Pasture renovation and establishment

The use supported by the environmental assessment for pasture renovation and establishment is for application at 188 g ac/ha. It was noted earlier that it is not clear if all the residue results for grass were reported on a fresh or dry weight basis, with exception of the JMPR cereal trials which were expressed on a dry weight basis. Residues of diquat in cereal straw 2-4 days after a pre-harvest application at 0.6 kg ai/ha were 0.27, 1.2, 1.8, 2.0, 2.4, 2.8 (3), 3.1, 3.3, 4.3, 5.6, 6.1, 6.2, 6.9, 23 and 26 mg/kg (dry weight). Scaled for application rate the HR is 8.1 mg/kg. It is also noted earlier that the levels of diquat residues in trials conducted on grasses and cereals were similar to those results found in legumes. Based on the assessment for lucerne above which was supported at the same application rate a Primary feed commodities MRL at 30 mg/kg will be established to cover these uses and will also cover crop establishment uses. The recommended grazing withholding period is one day.

5.12.6 Sugarcane

Environment have supported the pre-harvest desiccation of sugarcane. However, as residue data are not available to support the over-the-top use or pre-harvest desiccation of sugarcane these uses are no longer supported.

Noting the results of the pre-emergent trials on rice and maize where residues were <0.05 mg/kg, the sugarcane MRL at *0.05 mg/kg can remain in place to support the use of diquat as an aid in establishing sugarcane or controlling weeds in a fallow prior to sugarcane. The supported withholding period for the supported pre-emergent use on sugarcane is “Not required when used as directed”. The supported grazing withholding period is 1 day (see below).

5.12.7 Orchards (including bananas) and Vineyards: Citrus, Grapes, Pome fruit, Stone fruit, Tree nuts, Tropical fruit (edible peel), Tropical fruit (inedible peel, except pineapple)

These uses as a directed or inter-row spray were previously supported by Residues and MRLs at the LOQ were recommended for each crop group which remain appropriate. Use in vineyards will be covered by the berries MRL also at the LOQ as recommended below. The supported harvest withholding period is "Not required when used as directed".

A higher application rate (300 g ac/ha) has been supported for orchards and vineyards than in other potential grazing situations (up to 188 g ac/ha for pasture). It is noted that the plant material within orchards and vineyards is not commonly traded so does not need to be covered by the Primary feed commodities MRL recommended above. Residues in treated plant material within orchards would not cause any exceedance of the current animal commodity MRLs as considered previously. The supported grazing withholding period for treated areas in orchards and vineyards is 1 day.

5.12.8 Vegetables - Asparagus

Environment has supported the use on asparagus prior to spear emergence. The continued use of diquat on stalk and stem vegetables (including the specific asparagus use) was not supported in the initial residue review evaluation without specific and reliable residue data for the representative crops as residue data for other vegetable crops had indicated a potential for finite residues from the current use in row crops and market gardens for some crop groups.

However, in response to the initial consultation, Syngenta has submitted 2 European GLP residue studies on asparagus (see also evaluation of responses to the public consultation). In the first study, diquat was applied to the soil for control of weeds at 800 g ac/ha with residues <0.05 mg/kg (n = 2) in the spears at 3 – 4 days after treatment. In the second study, diquat was applied prior to spear emergence at 747 – 760 g ac/ha with residues in the spears <0.01 mg/kg (n = 2) at 11 – 20 days after treatment. Asparagus is only one representative crop for stalk and stem vegetables, with the others being celery and globe artichoke. The single trial provided previously for celery was considered not to be reliable. There is insufficient data to support the general use on the whole stalk and stem vegetable crop group. The general stalk and stem vegetable use is supported for asparagus only, along with the specific asparagus use prior to spear emergence. An MRL of *0.05 mg/kg is recommended for VS 0621 Asparagus in conjunction with a harvest withholding period of "Not required when used as directed".

5.12.9 Berries and other small fruit (except grapes)

The entry recommended earlier into the MRL Standard for berries and small fruits, was at the LOQ with finite residues not expected to occur. This entry should therefore remain appropriate for the reduced rate supported by the environmental assessment and should include grapes as a use on vineyards has been supported.

- FB 0018 Berries and other small fruits *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 berries and other small fruit.

5.12.10 Vegetables - Brassica vegetables: broccoli, head cabbages, cauliflower and Chinese cabbage (type Pe-tsai)

The entries into the MRL Standard recommended earlier for selected Brassica vegetables were at the LOQ with finite residues not expected to occur. These entries should remain appropriate for the reduced rate supported by the environmental assessment:

- VB 0400 Broccoli *0.02 mg/kg
- VB 0041 Cabbages, head *0.02 mg/kg
- VB 0404 Cauliflower *0.02 mg/kg
- VB 0467 Chinese cabbage (type Pe-tsai) *0.02 mg/kg

As the use is pre-emergence or by shielded spray, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for broccoli, cauliflower, cabbage and Chinese cabbage.

As before, in the absence of residues data for Brussels sprouts, which is a representative crop, use in Brussels sprouts or the entire brassica vegetable crop group is not supported due to a lack of relevant residues data (for Brussels sprouts).

5.12.11 Vegetables - Bulb vegetables: bulb onions

The highest residues reported in bulb onions which was relevant to the Australian use rate of 0.8 kg ac/ha was 0.10 mg/kg after 3 applications of 0.8 kg ac/ha. Scaled for the application rate of 283 g ac/ha supported by the environmental assessment, the estimated HR is 0.035 mg/kg.

The recommended entry into the MRL Standard for bulb onions is:

- VA 2031 Bulb onions 0.07 mg/kg

Although the HR was observed at 6–7 days after application at 0.8 kg ac/ha, a ‘Not required when used as directed’ withholding period is considered suitable for shielded spray application post emergence, noting also that lower residues were observed immediately after application and that an MRL has been recommended to cover the observed HR.

As before, the available diquat residues data supports continued use in the bulb onion subgroup, which includes bulb onions, shallots and garlic (among others). In the absence of residues data for spring onion or other members of the green onion subgroup, continued use in members of the green onion subgroup is not supported noting that finite residues may be expected and a robust assessment of the potential for residues in green onions cannot be performed without specific residues data.

5.12.12 Vegetables - Fruiting vegetables, cucurbits

This use was originally not supported with respect to Residues and Trade but has been supported for cucumber only post consultation.

Syngenta has submitted 5 European GLP residue studies conducted on field (5 trials) and protected (6 trials) cucumbers (see also evaluation of responses to the public consultation). In 11 trials involving inter-row application at 953 – 1232 g ac/ha (3.4× - 4.4×) highest residues at 0 – 8 days after treatment were <0.01 (7), 0.02 (2), <0.05 and 0.05 mg/kg. Residues were detected both in the field and in protected situations. Scaled for application rate residues are <0.01 (9) and <0.05 (2) mg/kg. Cucumber is a representative crop for cucurbits, but data for cantaloupe and summer squash are also required to support use on the whole crop group. Given that detectable residues were found in cucumber, the use is supported for cucumber only, not the cucurbit crop group. An MRL of *0.05 mg/kg is supported for VC 0424 Cucumber in conjunction with a harvest withholding period of “Not required when used as directed”.

5.12.13 Vegetables - Fruiting vegetables other than cucurbits

The entry into the MRL Standard recommended earlier for fruiting vegetables, other than cucurbits was at the predominant LOQ in the available trials of 0.01 mg/kg, noting that finite residues were not expected to occur. This entry should remain appropriate for the reduced rate supported by the environmental assessment.

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

As the use is pre-emergence or by shielded spray, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for fruiting vegetables, other than cucurbits.

5.12.14 Vegetables - Leafy vegetables

In trials that involved one to 2 applications at rates approximate to the Australian rate (0.7–1 kg ac/ha), residues were <0.01, 0.01, <0.02 (2), 0.03, 0.05 and 0.07 mg/kg at a 7–10 day PHI. Application rates were approximately 3× that supported by the environment assessment. Scaled for the supported rate residues are estimated as <0.01 (2), <0.02 (2), 0.01 and 0.02 (2) mg/kg. The OECD MRL Calculator recommends an MRL of 0.04 mg/kg. The recommended entry into the MRL Standard for Leafy vegetables based on the rate supported by the environmental assessment is:

- VL 0053 Leafy vegetables 0.05 mg/kg

As the use is pre-emergence or by shielded spray, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for leafy vegetables.

5.12.15 Vegetables - Legume vegetables

The entry recommended earlier into the MRL Standard for legume vegetables was at the LOQ, with finite residues not expected to occur. This entry should remain appropriate for the reduced rate supported by the environmental assessment:

- VP 0060 Legume vegetables *0.05 mg/kg

As the use is pre-emergence or by shielded spray, a harvest withholding period statement of ‘Not Required when used as directed’ is supported for legume vegetables.

5.12.16 Vegetables - Root and tuber vegetables

There were 13 overseas carrot trials conducted as pre-emergence and post-emergence weed control. Residues of diquat in these trials were generally <0.02 mg/kg, with a maximum of 0.07 mg/kg recorded in samples taken 14 days after an application of 1.0 kg ac/ha (3.5× the rate supported by environment). The maximum residue recorded after application at 0.8 kg ac/ha (2.8× the maximum rate supported by environment) was 0.04 mg/kg in the same trial (14 day PHI). In another trial, residues were all <0.02 mg/kg in samples taken one, 7, 13 and 20 days after an inter-row weed control application of 0.8 kg ac/ha. The PHI in all these trials ranged from one to 123 days and the shorter intervals would not reflect typical agronomic practice where application as a pre-emergence weed control is earlier in the crop growth cycle, or via shielded sprayer later in the growing cycle.

Diquat residues in root and tuber vegetables after pre-emergent or post emergent shielded spray application will be covered by an MRL recommended at 0.05 mg/kg in conjunction with a ‘Not required when used as directed’ harvest withholding period (the sugar beet MRL at 0.1 mg/kg will be deleted). This group MRL will cover the HR of 0.07 mg/kg observed in carrots after a pre-emergence application when scaled for application rate (HR = 0.02 mg/kg when scaled for the supported application rate of 0.283 kg ac/ha).

The supported MRL is:

- VR 0075 Root and tuber vegetables 0.05 mg/kg

5.12.17 Vegetables - Stalk and stem vegetables

As in the discussion for asparagus above, the general use is supported for asparagus only, along with the specific asparagus use prior to spear emergence. An MRL of *0.05 mg/kg is recommended for VS 0621 Asparagus in conjunction with a harvest withholding period of “Not required when used as directed”.

5.12.18 Wheat, oats

For wheat and oats, the alternative use pattern supported by the environmental assessment allows application at 140 g ai/ha between the 4 leaf stage (for wheat) or 3 leaf stage (for oats) up to early tillering.

In Australian wheat trials considered by the 2018 JMPR and provided in full for this review, residues in wheat grain after 2 applications at approximately 140 g ac/ha with the first at BBCH 24-29 and the second at BBCH 24-52 were 0.04, 0.14, 0.22, 0.26, 0.28, 0.29, 0.30 and 0.34 mg/kg.

Similarly for oat grain with the first application at BBCH 24 and the second at BBCH 24-45 residues were 0.13, 0.13, 0.19 and 0.21 mg/kg. (end of tillering = BBCH 29; for wheat the HR was observed when the last application was at BBCH 26, for oats the HR was observed when the last application was at BBCH 25). Based on the combined data set the OECD MRL Calculator recommends an MRL of 0.7 mg/kg (STMR = 0.215 mg/kg, n = 12). MRLs of 0.7 mg/kg are recommended for GC 0647 Oats and GC 0654 Wheat to cover the alternative use pattern supported by environment in conjunction with a harvest withholding period of “Not required when used as directed”.

In Australian wheat trials considered by the 2018 JMPR and provided in full for this review, residues in wheat forage at 1 day after application at approximately 140 g ac/ha were 10, 13, 15 and 15 mg/kg on a dry weight basis.

Similarly for oat forage residues were 3.6 and 13 mg/kg on a dry weight basis. The OECD MRL Calculator recommends an MRL of 40 mg/kg (unrounded 34.8 mg/kg, STMR 13 mg/kg, n = 6). The available data for grass and cereal forage and fodder suggests that residues should be below 30 mg/kg, the level of the Primary Feed Commodities MRL recommended above, noting that the levels of diquat residues in trials conducted on grasses and cereals were similar to those results found in legumes. The supported grazing withholding period is 1 day.

5.12.19 Aquatic areas

Use of diquat in aquatic areas with the 10 day restraint on using water for human consumption, livestock watering or irrigation purposes continues to be supported from a residues and trade perspective

5.12.20 Animal commodities

Current MRLs are *0.05 mg/kg for meat (mammalian) and edible offal (mammalian) and *0.01 mg/kg for milks. Data from the animal transfer studies indicate that a dietary intake of 100 ppm would not produce detectable residues in the meat or offal and a dietary intake of 1,000 ppm would not produce detectable residues in the milk. The submitted residues studies support Table 4 entries of 30 mg/kg for primary feed commodities. Therefore, finite residues in meat, offal and milks are not expected to occur based on the current maximum dietary intake for ruminants and pigs. The current mammalian commodity MRLs remain appropriate.

Diquat residues above the LOQ of 0.01 mg/kg for eggs and 0.05 mg/kg for meat and offal were not observed in a poultry feeding study conducted at a feeding level of 10 ppm. The poultry commodity MRLs at the LOQ can also remain in place to indicate that finite diquat residues should not occur in poultry commodities for the supported uses (including wheat and oats).

5.12.21 Trade

Cereals, pulses and oilseeds include major export commodities. However, residues are not expected to occur at harvest following the supported pre-emergent uses and reduced MRLs have been recommended for wheat and oats to cover the use pattern that allows application up to early tillering. Hops are not considered to be a major export commodity and detectable residues are not expected to occur in hops. The supported vegetable crops are also not major export commodities. Residues should also not occur in livestock grazing treated crops or pasture. The risk to trade from the supported uses is considered to be low.

5.13 Revised dietary exposure assessment

5.13.1 Chronic dietary exposure assessment

The chronic dietary exposure to diquat 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 diquat is equivalent to <20% of the ADI, for the uses proposed to be supported by the APVMA chemical review.

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

5.13.2 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 <2% of the ARfD, for the uses proposed to be supported by the APVMA chemical review. It is concluded that the acute dietary exposure is acceptable.

5.14 Revised MRL changes

The amendments shown in Table 22 and Table 23 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 are proposed to remain at the completion of the APVMA chemical review.

Table 22: Revised amendments to Table 1 of the MRL Standard

Code	Commodity	Current MRL	Recommended MRL
VS 0621	Asparagus	-	*0.05
FT 0026	Assorted tropical and sub-tropical fruits – edible peel	-	*0.1
FI 0030	Assorted tropical and sub-tropical fruits – inedible peel {except pineapple}	-	*0.02
GC 0640	Barley	5	Delete
VP 0061	Beans, except broad bean and soya bean	1	Delete
FB 0018	Berries and other small fruits	–	*0.05
VP 0522	Broad bean (green pods and immature seeds)	1	Delete
VB 0400	Broccoli	–	*0.02
VA 2031	Bulb onions	–	0.07
VB 0041	Cabbages, head	–	*0.02
VB 0404	Cauliflower	–	*0.02
GC 0080	Cereal grains {except Oats; Wheat}	–	*0.05
VB 0467	Chinese cabbage (type Pe-tsai)	–	*0.02

Code	Commodity	Current MRL	Recommended MRL
FC 0001	Citrus fruits	-	*0.05
VS 0424	Cucumber	-	*0.05
MO 0105	Edible offal (Mammalian)	*0.05	*0.05
PE 0112	Eggs	*0.01	*0.01
VO 0050	Fruiting vegetables, other than cucurbits	–	*0.01
	Fruits	*0.05	Delete
DH 1100	Hops, dry	0.2	*0.05
VL 0053	Leafy vegetables	–	0.05
VP 0060	Legume vegetables	–	*0.05
SO 0693	Linseed	*0.01	Delete
GC 0645	Maize	0.1	Delete
MM 0095	Meat [mammalian]	*0.05	*0.05
ML 0106	Milks	*0.01	*0.01
GC 0647	Oats	5	0.7
SO 0088	Oilseed [except linseed and poppy seed]	5	Delete
SO 0088	Oilseed {except poppy seed}	–	*0.05
SO 0305	Olives for oil production	-	*0.1
VA 0385	Onion, Bulb	0.1	Delete
VP 0063	Peas	0.1	Delete
FP 0009	Pome fruits	-	*0.01
SO 0698	Poppy seed	*0.01	*0.01
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	*0.05
GC 0649	Rice	5	Delete

Code	Commodity	Current MRL	Recommende d MRL
CM 1205	Rice, polished	1	Delete
VR 0075	Root and tuber vegetables	–	0.05
GC 0650	Rye	2	Delete
GC 0651	Sorghum	2	Delete
FS 0012	Stone fruits	-	*0.01
VR 0596	Sugar beet	0.1	Delete
GS 0659	Sugar cane	*0.05	*0.05
TN 0085	Tree nuts	*0.05	*0.05
GC 0653	Triticale	2	Delete
	Vegetables [except beans; broad bean; lupin (dry); onion, bulb; peas; potato; soya bean (dry); sugar beet]	*0.05	Delete
OC 0172	Vegetable oils, crude	1	Delete
OR 0172	Vegetable oil, edible	-	*0.01
GC 0654	Wheat	2	0.7

Table 23: Revised amendments to Table 4 of the MRL Standard

Code	Animal feed commodity	Current MRL	Recommended MRL
AL 0157	Legume animal feeds	100	Delete
	Oilseed forage and fodder	30	Delete
	Primary feed commodities	–	30

6 Environmental safety

6.1 Assessment scenarios

Diquat products are registered for control of aquatic weeds that can be injected below the surface to achieve a target concentration of 1.0 mg ac/L (for control of cattails and pond weeds) or applied as a surface spray at 1,000 to 2,000 g ac/ha with a minimum retreatment interval of 7 days (to control floating weeds). A second spray application may be necessary for control of dense infestations. Oxygen depletion of decaying weeds may occur; therefore, no more than a quarter of the area should be treated as a surface spray per application to ensure adequate oxygen supply for aquatic life (i.e. environmental exposure across the entire water body is equivalent to 250 to 500 g ac/ha).

Diquat products are also registered as pre-harvest desiccants in a variety of crops at rates up to 800 g ac/ha.

Additionally, diquat products are registered for general weed control in a variety of crop and pasture situations at rates up to 800 g ac/ha. Applications are generally before planting or before crop emergence (i.e., bare soil scenarios); however, applications can also occur at later crop stages as directed sprays or inter-row treatments.

This assessment addresses the risks of diquat only, for all relevant uses. Risks of the combination of paraquat and diquat have been assessed separately for relevant uses and can be found in the *Paraquat Review Technical Report*. The environmental risk assessment scenarios considered in the assessment are summarised in Table 24. Environmental risks were determined according to contemporary methodology outlined in the APVMA Risk Assessment Manual – Environment.

Table 24: Environmental risk assessment scenarios for diquat

Category [23]	Situation	Risk assessment scenario
Aquatic areas	Water injection	1× 1.0 mg ac/L
	Surface spray	2× 500 g ac/ha 7-day retreatment interval
Pre-harvest crop desiccation	Potatoes, sweet potatoes	1× 300–800 g ac/ha
	Poppies	1× 600–800 g ac/ha

[23] For products containing only diquat categorisation is based on the broad use type.

Category [23]	Situation	Risk assessment scenario
	Oilseeds, lupins, lucerne, pulses	1× 300–600 g ac/ha
	Cereals, rice, sunflowers	1× 400–600 g ac/ha
	Sugarcane	1× 200–600 g ac/ha
	Cotton	1× 140–600 g ac/ha
General weed control	Row crops, vegetables, market gardens	1× 280–800 g ac/ha
	Wheat and oats	1× 110–600 g ac/ha
	Pasture	1× 150–300 g ac/ha
	Infested areas	1× 60-1333 g ac/ha
	Oilseeds	1× 60–300 g ac/ha
	Orchards, vineyards	1× 300 g ac/ha
	Hops	1× 140–280 g ac/ha
	Lucerne	1× 70–140 g ac/ha

6.2 Fate and behaviour in the environment

Diquat is very persistent and non-mobile in soil, with low risk of leaching to groundwater. However, diquat is more mobile in sandy soils than in agricultural soils with higher clay content (>10% clay). Therefore, it is proposed to assess sand and non-sand soils separately.

A reliable definitive DT_{50} value for degradation in soil is not available. Therefore, it is proposed to use the default DT_{50} for persistent substances (1000 days) for risk assessment; this is considered reasonably conservative for residues that may be biologically available. However, where accumulation of strongly bound residues needs to be considered a DT_{50} of 41 years is recommended.

In aquatic systems, diquat is highly soluble, but partitions rapidly to the sediment where it strongly sorbs and is very persistent. Therefore, as for soil, the default DT_{50} of 1000 days for persistent substances is also proposed for sediment. The mean K_f from the dataset for sediment (i.e. 136759 mL/g, 1/n 0.98) is proposed for predicting sediment concentrations of diquat. The field DT_{50} of 0.50 days is considered representative of the dissipation rate of diquat in natural waters.

Diquat is not volatile and is unlikely to be subject to long-range atmospheric transport.

Available residue data indicate diquat dissipates rapidly from animal food items such as foliage (geomean DT_{50} 1.8 days) and insects (geomean DT_{50} 2.2 days), whereas the dissipation rate was longer on seeds (geomean DT_{50} 7.9 days).

The key regulatory endpoints for the environmental exposure assessment are summarised in Table 25. A full listing of endpoints is provided in Appendix B.

Table 25: Key regulatory endpoints for environmental exposure assessment

Compartment	Value		Reference
Animal food items	Foliage: DT_{50} 1.8 d		Edwards, et al, 1991; Kennedy, 1984a; Langridge, 2011a; 2011b; Massey, 1987c
	Insects: DT_{50} 2.2 d		Edwards, et al, 1991; Jutsum, 2011
	Seeds: DT_{50} 7.9 d		Edwards et al, 1991
Soil	DT_{50} 1000 d		Default for persistent substances, for residues in solution
	DT_{50} 41 years		Estimate based on Dyson & Chapman 1991 for residues bound to soil
	Sands:	K_f 349 mL/g, 1/n 0.59	Dixon & Gilbert, 2012b; Mônego, 2005; Pack, 1987
	Non-sands:	K_f 2517 mL/g, 1/n 0.76	
	10th percentile soil:	K_f 62 mL/g, 1/n 0.47	
Water	DT_{50} 0.50 d		Fujie, 1988d
Sediment	DT_{50} 1000 d		Default for persistent substances
	K_f 136759 mL/g		Mônego, 2005; Pack, 1987
Air	DT_{50} 5.5 h		Hayes, 2001

6.3 Effects on non-target species

Diquat has moderate toxicity to mammals (LD_{50} 120 mg ac/kg bw, *Rattus norvegicus*) and high toxicity to birds (geomean LD_{50} 70 mg ac/kg bw, 3 species). Based on the available information, for the purpose of setting the RAL, the mammalian LD_{50} is accepted to be 208 mg ac/kg bw; this is consistent with the assessment by EFSA (2015). Therefore, the following protection statement is recommended on diquat product labels, followed by an appropriate risk management statement.

Toxic to birds.

Following long-term dietary exposure in a multi-generation reproductive toxicity study, fewer F1 pups/litter and reduced F1 body weight gain in mammals during lactation were observed at doses as low as 12 mg ac/kg bw/d (NOAEL 4.0 mg ac/kg bw/d, *Rattus norvegicus*).

Higher tier reproductive toxicity studies are available on the most sensitive species of bird (*Anas platyrhynchos*) that considered 9 weeks of exposure (3 weeks prior to full egg production and 6 weeks during full egg production). Biologically relevant reductions in egg production were observed at dietary concentrations as low as 40 mg ac/kg food (NOEC 20 mg ac/kg food; equivalent to NOEL 3.2 mg ac/kg bw/d). An additional study suggested that egg production can recover providing that exposure is early in the egg production period and the egg laying period of exposed birds is sufficiently long (Temple et al. 2009).

Diquat has moderate toxicity to fish (lowest LC_{50} 750 µg ac/L, *Sander vitreus*) and aquatic invertebrates (lowest LC_{50} 420 µg ac/L, *Americamysis bahia*), and high toxicity to sediment dwellers (LC_{50} 84 µg ac/L, *Hyallella azteca*), algae (lowest E_rC_{50} 1.2 µg ac/L, *Navicula pelliculosa*) and aquatic plants (EC_{50} 3.2 µg ac/L, *Lemna gibba*). Therefore, the following protection statement is recommended on diquat product labels.

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

Following life-cycle exposure of pond snails to contaminated water, increased embryonic stage duration, delayed first spawning and reduced food consumption were observed at concentrations as low as 3.2 µg ac/L (NOEC 1.1 µg ac/L, *Lymnaea stagnalis*). Reduced growth of fish and aquatic invertebrates was observed at concentrations as low as 320 µg ac/L (NOEC 120 µg ac/L, *Pimephales promelas*) and 110 µg ac/L (NOEC 52 µg ac/L, *Americamysis bahia*), respectively.

Following long-term exposure of amphipods to contaminated sediment, reduced reproduction was observed at concentrations as low as 23 mg ac/kg dry sediment (NOEC 11 mg ac/kg dry sediment, *Hyallela azteca*). It is noted that the clay content in the test sediment was relatively low (3%). No adverse effects were observed in 2 species of midges at the highest sediment concentrations tested (NOEC 37 mg ac/kg dry sediment, *Chironomus dilutus*; NOEC 100 mg ac/kg dry sediment, *Chironomus riparius*), noting the clay content in the test sediments ranged from 20–25%.

The effects of spray application or water injection of an SL 240 g/L formulation on non-target aquatic plants were investigated under field conditions in Florida and Wisconsin. A wide range of sensitivities was observed between the tested aquatic plants. These sensitivities were often related to the ability of the plant to recover over a 4 to 5 week observation period following application. Duckweed (*Spirodela punctata*) was the most sensitive species following exposure both as a foliar spray (ER_{50} 3.5 g ac/ha) and water injection (ER_{50} 3.1 µg ac/L). Sediment seemed to afford some protection to sub-soil vegetative portions of plants that are not free-floating (for example, hydrilla and torpedo grass). This indicates that perennial plants with a significant underground biomass could be resistant to diquat, with the exception of some temporary damage.

A measured BCF of 1.0 in bluegill sunfish shows that diquat is unlikely to accumulate in fish (Hamer et al. 1987).

Noting primary producers are most sensitive to diquat, an SSD analysis was performed on the laboratory toxicity data. Diquat 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. For primary producers, the resulting HC_5 (Table 26) is summarised below. Given there is uncertainty regarding the TWA adjustment and the wide confidence intervals around the HC_5, an assessment factor of 3 is recommended. The RAL for primary producers is therefore 0.0014 mg ac/L (HC_5 0.0042 mg ac/L and assessment factor of 3 [24]).

The RALs for risk assessment are 0.0014 mg ac/L for aquatic species (primary producers), and 11 mg ac/kg ds for sediment dwellers (Table 26). To assess risks in aquatic situations where aquatic weeds are targeted, the most conservative RAL of 47 µg ac/L for aquatic animals was selected, which was also adjusted to account for rapid dissipation under natural conditions [25].

Diquat has low toxicity to bees by contact exposure (LD_{50} 105 µg ac/bee, *Apis mellifera*) and moderate toxicity by oral exposure (LD_{50} 22 µg ac/bee, *Apis mellifera*). The RAL for spray drift assessment is 17,500 g ac/ha based on the contact LD_{50} 105 µg ac/bee and a conversion factor of LOC 0.4 / ExpE 2.4 * 1000 as per the APVMA's Spray drift risk assessment manual (SDRAM).

In Tier 1 (glass plate) laboratory tests on the toxicity of an SL formulation of diquat to the indicator species of predatory arthropods (predatory mite *Typhlodromus pyri*) and parasitic arthropods (parasitic wasp *Aphidius rhopalosiphi*), the respective LR_{50} values were 2.9 and 3.2 g ac/ha. Exposure under Tier 2 (natural substrate) conditions did not influence toxicity to the predatory mite (LR_{50} 4.1 g ac/ha, *Typhlodromus pyri*). However, toxicity to the parasitic wasp was reduced (LR_{50} 758 g ac/ha, *Aphidius rhopalosiphi*). Soil dwelling arthropods such as carabid beetles, spiders and rove beetles were unaffected at field relevant rates.

Diquat has moderate toxicity to soil macro-organisms such as earthworms (LC_{50} 94 mg ac/kg dry soil, *Eisenia fetida*). Following long-term exposure, reduced reproduction of collembolans was observed at concentrations as low as 12 mg ac/kg dry soil (NOEC 9.4 mg ac/kg dry soil, *Folsomia candida*). No adverse effects were observed on other soil macro-organisms at the highest tested soil concentrations (NOEC 37 mg ac/kg dry soil, *Eisenia fetida*; NOEC 50 mg ac/kg dry soil, *Hypoaspis aculeifer*). It is noted that the laboratory tests were conducted in artificial soils containing 20% clay, which may not represent realistic worst-case exposure systems (i.e. compared to soils with lower capacity to adsorb and deactivate diquat). It is also noted that effects on earthworm numbers and weight were observed under representative field conditions after one year; however, no differences were observed for several years thereafter.

Following long-term exposure to the metabolite TOPPS, reduced reproduction and biomass of earthworms were observed at soil concentrations as low as 160 mg/kg dry soil (NOEC 80 mg ac/kg dry soil, *Eisenia fetida*), and reduced reproduction of collembolans was observed at concentrations as low as 259 mg/kg dry soil (NOEC 144 mg/kg dry soil, *Folsomia candida*). No adverse effects were observed on soil mites at the highest tested soil concentration (NOEC 320 mg/kg dry soil, *Hypoaspis aculeifer*).

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[24] Assessment factor 3 for primary producers is based on EFSA (2013a)

[25] Based on 4-day LC_{50} 84 µg ac/L (*Hyallela azteca*) and assessment factor of 10

Diquat did not adversely affect soil processes such as nitrification at soil concentrations up to 500 mg ac/kg dry soil. Similarly, a litter-bag study showed that exaggerated soil concentrations have no functional impairment on the soil organisms contributing to organic matter breakdown.

A representative SL formulation of diquat had low toxicity to non-target terrestrial plants following pre-emergent exposure to soil residues under laboratory conditions (lowest ER_{25} 25 kg ac/ha, *Zea mays*). However, because diquat is a non-selective contact herbicide, foliar exposure is the exposure route of greatest concern. Under laboratory conditions, cabbage was the most sensitive species following foliar exposure (ER_{50} 15 g ac/ha, *Brassica oleracea*). Under field conditions, a natural stand of yellow nutsedge was the most sensitive based on visual injury (ER_{50} 35 g ac/ha, *Cyperus esculentus*); sunflower was the next most sensitive species based on dry weight (ER_{50} 50 g ac/ha, *Helianthus annuus*).

An SSD analysis was performed on the post-emergent ER_{50} values for 10 non-target terrestrial plant species. The resulting HR_5 (Table 27) is summarised below. The RAL for the spray drift assessment is 15 g ac/ha. The 3-hour EC_{50} of diquat on activated sewage sludge was >220 mg ac/L (Clarke 2009).

In terms of endocrine disrupting properties of diquat, there is strong evidence for adverse *in vivo* effects on sexually reproducing molluscs, but the effects were not necessarily caused by endocrine disruption. Results in remaining non-mammalian species are largely equivocal. 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 diquat.

The regulatory acceptable levels for the environmental risk assessment are proposed in the table below. The RAL values for the spray drift assessment are 1.4 µg ac/L for the protection of natural aquatic areas, 17,500 g ac/ha for the protection of pollinator areas, and 15 g ac/ha for the protection of vegetation areas.

Table 26: Toxicity endpoints for aquatic primary producers used in SSD analysis

Species	Exposure days	Measured EC_{50}	Adjusted EC_{50}	Notes
Navicula pelliculosa	3 d	0.0012 mg ac/L	0.0051 mg ac/L	
Nitzschia palea	4 d	0.0052 mg ac/L	0.029 mg ac/L	
Achnanthidium minutissimum	4 d	0.0073 mg ac/L	0.041 mg ac/L	
Lemna gibba	14 d	0.0032 mg ac/L	0.062 mg ac/L	
Anabaena flos-aquae	3 d	0.025 mg ac/L	0.11 mg ac/L	
Raphidocelis subcapitata	4 d	0.055 mg ac/L	0.31 mg ac/L	
Pseudanabaena foetida	4 d	0.23 mg ac/L	1.3 mg ac/L	
Synechococcus leopoliensis	4 d	0.29 mg ac/L	1.6 mg ac/L	
Fistulifera pelliculosa	4 d	0.33 mg ac/L	1.8 mg ac/L	
Desmodesmus subspicatus	4 d	3.2 mg ac/L	18 mg ac/L	
Skeletonema costatum	3 d	12 mg ac/L	51 mg ac/L	

Species	Exposure days	Measured EC_{50}	Adjusted EC_{50}	Notes
	HC_5	0.00069 mg ac/L (95% CI 0.000008-0.010)	0.0042 mg ac/L (95% CI 0.000036-0.062)	Model average result[26] based on gamma, log-gumbel, log-logistic, log-normal, log-normal_log-normal, and Weibull distributions (11 species)

Endpoints from Table 62 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} 0.5 days))) * (exposure days * ln(2)/DT_{50} 0.5 days)

Table 27: Post-emergent toxicity endpoints for non-target terrestrial plants used in SSD analysis

Species	ER_{50}	Note
Brassica oleracea	15 g ac/ha	
Beta vulgaris	38 g ac/ha	
Helianthus annuus	53 g ac/ha	(Geomean of 3 studies)
Daucus carota	53 g ac/ha	
Gossypium hirsutum	55 g ac/ha	
Brassica napus	57 g ac/ha	
Glycine max	138 g ac/ha	(Geomean of 3studies)
Pinus strobes	150 g ac/ha	
Pinus elliottii	293 g ac/ha	
Phaseolus vulgaris	884 g ac/ha	
HR_5	15 g ac/ha (95% CI 3.1–43)	Model average result[27] based on gamma, log-gumbel, log-logistic, log-normal, log-normal_log-normal, and Weibull distributions (10 species)

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

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

Table 28: Regulatory acceptable levels for non-target species

Group	Exposure	Endpoint	AF	RAL	Reference
Mammals	Acute	LD_{50} 208 mg/kg bw	10	21 mg/kg bw	Rittenhouse 1979, McCall & Robinson 1990
	Chronic	NOAEL 4.0 mg/kg bw/d	1	4.0 mg/kg bw/d	Hodge 1990
Birds	Acute	LD_{50} 70 mg/kg bw	10	7.0 mg/kg bw	Fink et al. 1982, Hubbard 2013, Roberts & Fairley 1980
	Chronic	NOEL 3.2 mg/kg bw/d	1	3.2 mg/kg bw/d	Temple et al. 2004a, 2004b
Aquatic animals	Acute	LC_{50} 468 µg/L*	10	47 µg/L	Bender 2006a
Aquatic primary producers	Chronic	HC_5 4.2 µg/L*	3	1.4 µg/L	Magor & Shillabeer 2001, Nagai 2019, Smyth et al. 1998a, 1998b, 1998c
Sediment dwellers	Chronic	NOEC 11 mg/kg ds	1	11 mg/kg ds	Bradley 2013a
Adult bees	Acute contact	LD_{50} 105 µg/bee	2.5	42 µg/bee	Gough et al. 1987
	Acute oral	LD_{50} 22 µg/bee	2.5	8.8 µg/bee	Gough et al. 1987
Foliar arthropods	Contact	LR_{50} 4.1 g/ha	1	4.1 g/ha	Austin & Elcock 1999b
Ground arthropods	Contact	ER_{50} >1000 g/ha	1	1000 g/ha	Beech 1997
Soil macro-organisms	Acute	LC_{50} 94 mg/kg ds	10	9.4 mg/kg ds	Bender 2006b
	Chronic	NOEC 9.4 mg/kg ds	1	9.4 mg/kg ds	Friedrich 2007b
Soil micro-organisms	Chronic	NOEC 500 mg/kg ds	1	500 mg/kg ds	Schultz 2007b
Terrestrial plants	Post-emergent	HR_5 15 g ac/ha	1	15 g/ha	Bellet 1990b, Martin 2013, Porch & Krueger 1999

*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} 0.5 days))) * (exposure days * ln(2)/DT_{50} 0.5 days)

6.4 Risks to non-target species

6.4.1 Terrestrial vertebrates

Direct dietary exposure of terrestrial vertebrates to diquat is considered negligible following application to aquatic areas. Therefore, risks to terrestrial vertebrates are acceptable for application in aquatic areas. Direct dietary exposure is possible for uses of diquat as a pre-harvest crop desiccant or for 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 updated assessments, the maximum supported rates differ according to crops and situations within each use pattern:

- Pre-harvest crop desiccation: 122 to 1591 g ac/ha, depending on the crop (122 g ac/ha for cereals and rice; 278 g ac/ha for lucerne, lupins, potatoes, sweet potatoes, and pulses; 283 g ac/ha for oilseeds; 323 g ac/ha for sunflowers; 600 g ac/ha for sugarcane; 800 g ac/ha for poppies; and 1591 g ac/ha for cotton).
- General weed control: 122 to 560 g ac/ha, depending on the situation (122 g ac/ha for pre-harvest cereals; 230 g ac/ha for pasture or cereals up to tillering; 261 g ac/ha for lucerne; 283 g ac/ha for asparagus, hops, market gardens, row crops, and vegetables; 300 g ac/ha for oilseeds; 464 g ac/ha for orchards and vineyards; and 560 g ac/ha for infested areas).

For mammals, the acute RAL was adjusted to account for acute toxicity data, alongside quantitative refinements for non-eutherian daily energy expenditure, a 50 g small herbivore body weight adjustment to reflect Australian fauna, in addition to other modification to the risk assessment. Based on the updated assessments, the maximum supported rates differ according to crops and situations within each use pattern:

- Pre-harvest crop desiccation: 610 to 1875 g ac/ha, depending on the crop (610 g ac/ha for cotton, sugarcane, and sunflowers; 625 g ac/ha for pulses; 938 g ac/ha for oilseeds and poppies; 1250 g ac/ha for lucerne, lupins, potatoes, and sweet potatoes; and 1875 g ac/ha for cereals and rice).
- General weed control: 188 to 1875 g ac/ha, depending on the situation (188 g ac/ha for pasture, orchards, and vineyards; 494 g ac/ha for cereals up to tillering; 560 g ac/ha for infested areas; 1209 g ac/ha for lucerne; 1455 g ac/ha for asparagus, hops, market gardens, oilseeds, row crops, and vegetables; and 1875 g ac/ha for pre-harvest cereals).

A full assessment for terrestrial vertebrates for the different use patterns is presented in Appendix C. The risk assessment conclusions are summarised in Table 29. Uses are not supported unless the application rate is restricted to the maximum supported rate indicated in Table 29. For use patterns where an acceptable risk can be concluded the following protection labelling is appropriate.

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

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

Table 29: Summary of risk assessment outcomes for terrestrial vertebrates

Category	Situation	Rate range (g ac/ha)[28]	Wild mammal assessment	Bird assessment	Maximum supported rate[29]
Pre-harvest crop desiccation	Cereals, rice	1× 400-600	Acceptable up to 1875 g ac/ha	Acceptable up to 122 g ac/ha	122 g ac/ha
	Cotton	1× 140-600	Acceptable up to 610 g ac/ha	Acceptable up to 1591 g ac/ha	600 g ac/ha
	Lucerne, lupins	1× 300-600	Acceptable up to 1250 g ac/ha	Acceptable up to 278 g ac/ha	278 g ac/ha
	Sugarcane	1× 400-600	Acceptable up to 610 g ac/ha	Acceptable up to 600 g ac/ha (WOE)	600 g ac/ha
	Sugarcane (hand spraying)	1× 200 (80, FFT 0.4)	Acceptable up to 610 g ac/ha	Acceptable up to 600 g ac/ha	600 g ac/ha
	Poppies	1× 600-800	Acceptable up to 938 g ac/ha	Acceptable up to 800 g ac/ha (WOE)	800 g ac/ha (WOE)

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

[29] 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 189 g ac/ha would be per application, for this number of applications and interval)

Category	Situation	Rate range (g ac/ha)[28]	Wild mammal assessment	Bird assessment	Maximum supported rate[29]
	Oilseeds	1× 300-600	Acceptable up to 938 g ac/ha	Acceptable up to 283 g ac/ha	283 g ac/ha
	Potatoes (haulm desiccation), sweet potatoes	1× 600-800	Acceptable up to 1250 g ac/ha	Acceptable up to 278 g ac/ha	278 g ac/ha
	Potatoes (pre-harvest)	1× 300	Acceptable up to 1250 g ac/ha	Acceptable up to 278 g ac/ha	278 g ac/ha
	Pulses	1× 400-600	Acceptable up to 625 g ac/ha	Acceptable up to 278 g ac/ha	278 g ac/ha
	Sunflower	1× 400-600	Acceptable up to 610 g ac/ha	Acceptable up to 323 g ac/ha	323 g ac/ha
General weed control	Market gardens, row crops, vegetables	1× 280-800	Acceptable up to 1455 g ac/ha	Acceptable up to 283 g ac/ha	283 g ac/ha
	Market gardens, row crops, vegetables (shielded inter-row spraying)	1× 280-800	Acceptable up to 1455 g ac/ha	Acceptable up to 283 g ac/ha	283 g ac/ha
	Oilseeds	1× 60-300	Acceptable up to 1455 g ac/ha	Acceptable up to 300 g ac/ha (WOE)	300 g ac/ha (WOE)
	Hops	1× 140-280	Acceptable up to 1455 g ac/ha	Acceptable up to 283 g ac/ha	283 g ac/ha
	Hops (directed inter-row spraying)	1× 140-280 (56-112, FFT 0.4)	Acceptable up to 1455 g ac/ha	Acceptable up to 283 g ac/ha	283 g ac/ha
	Asparagus	1× 280	Acceptable up to 1455 g ac/ha	Acceptable up to 283 g ac/ha	283 g ac/ha
	Cereals (pre-harvest)	1× 200-600	Acceptable up to 1875 g ac/ha	Acceptable up to 122 g ac/ha	122 g ac/ha
	Cereals (up to tillering)	1× 110-140	Acceptable up to 494 g ac/ha	Acceptable up to 230 g ac/ha	230 g ac/ha

Category	Situation	Rate range (g ac/ha) [28]	Wild mammal assessment	Bird assessment	Maximum supported rate [29]
	Pasture (grazed before spraying)	1× 150-300	Acceptable up to 188 g ac/ha	Acceptable up to 230 g ac/ha	188 g ac/ha
	Infested areas	1× 560	Acceptable up to 560 g ac/ha (WOE)	Acceptable up to 560 g ac/ha (WOE)	560 g ac/ha (WOE)
	Infested areas (knapsack sprayer and spot spraying)	1× 60-1333 (24-533, FFT 0.4)	Acceptable up to 560 g ac/ha (WOE)	Acceptable up to 560 g ac/ha (WOE)	560 g ac/ha (WOE)
	Lucerne (grazed before spraying)	1× 70-140	Acceptable up to 1209 g ac/ha	Acceptable up to 261 g ac/ha	261 g ac/ha
	Orchards	1× 300	Acceptable up to 188 g ac/ha	Acceptable up to 464 g ac/ha	188 g ac/ha
	Orchards (directed spray under trees and inter-row spraying)	1× 300 (120, FFT 0.4)	Acceptable up to 188 g ac/ha	Acceptable up to 464 g ac/ha	188 g ac/ha [30]
	Vineyards	1× 300	Acceptable up to 188 g ac/ha	Acceptable up to 464 g ac/ha	188 g ac/ha
	Vineyards (directed spray under vines and inter-row spraying)	1× 300 (120, FFT 0.4)	Acceptable up to 188 g ac/ha	Acceptable up to 464 g ac/ha	188 g ac/ha [31]

[30] Although directed and inter-row spraying is acceptable up to 300 g ac/ha when a 40% fraction of the field is sprayed for diquat, the instructions for use in orchards include an obligatory tank mix with paraquat at rates which pose an unacceptable risk for mammals.

[31] Although directed and inter-row spraying is acceptable up to 300 g ac/ha when a 40% fraction of the field is sprayed for diquat, the instructions for vineyards include an obligatory tank mix with paraquat at rates which pose an unacceptable risk for mammals.

6.4.2 Aquatic species

As indicated in Table 28 the RAL for the spray drift assessment is 1.4 µg ac/L for the protection of natural aquatic areas. Risks of spray drift are addressed separately, as needed.

For uses in aquatic areas, the risk assessment considered direct treatment of a shallow aquatic habitat. For acceptable risk, there must be no concerns identified for aquatic animals (RAL 47 µg ac/L) under this scenario. Acceptable risks of diquat could not be concluded for water injection at 1.0 mg ac/L or spray applications at rates as low as 1000 g ac/ha (Table 30). A lower spray rate is registered when used in combination with Agral Spray Adjuvant (product no. 54116); however, this adjuvant contains ethoxylated nonylphenol which is considered to be harmful to aquatic life and should not be used in aquatic situations (Brooke 1993, ECHA 2014, Lussier et al. 2000). Therefore, use of diquat products in aquatic areas was not supported in the proposed regulatory decision.

During consultation the following options have been proposed to mitigate the risk for aquatic use situations:

- Restriction of use to farm dams, irrigation channels, artificial watercourses, and managed waterways. Restriction of use to situations where exposure of natural aquatic areas will not occur could be used to resolve the risk (of both diquat and Agral Spray Adjuvant) for use in aquatic situations. The on-label use description would need to be updated, and the following restraint statement is recommended:
  - DO NOT apply to water bodies from which the product may contaminate natural aquatic areas.

For terrestrial uses, a runoff assessment according to APVMA's method to refine estimates of pesticide runoff to waterways [32] considered the lowest RAL values of 1.4 µg ac/L and 11 mg ac/kg dry sediment and assumed a runoff event occurs three days after the last application. 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.

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. The rainfall value is set at 8 mm, with 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.

For aquatic organisms, an acceptable risk can be concluded based on the geomean K_f and 1/n estimates (Table 31). For the 10th percentile of all soils, the risk is not acceptable when a DT_{50} of 41 years is used to estimate

[32] See Appendix B, Attachments 1 and 2 of https://apvma.gov.au/node/46416

accumulation of residues in soil [33]. However, it should be noted that using the 10th percentile K_f and 1/n values, the concentration in solution would be 0.01 mg ac/L at a soil concentration of 7.1 mg ac/kg ds. This concentration in solution is equivalent to the predicted concentration in solution at the strong adsorption capacity-wheat bioassay (SAC-WB) value for a soil, which approximates the soil concentration at which the soil binding capacity has been reached.

More rapid degradation of diquat is expected in solution due to microbial activity, and diquat in solution will be available for dissipation by environmental transport processes. Accumulation of residues is expected to be constrained by these factors, which are not reflected in the estimated accumulated peak soil concentration (18.3 mg ac/kg ds, assuming a DT_{50} of 41 years, Table 31). Accepting an application rate of 800 g ac/ha once per year and a DT_{50} of 41 years, a concentration of 7.1 mg ac/kg ds (i.e., the soil binding capacity) would be reached after approximately 7 years. As a simplistic and conservative approach, if for the next 13 years, the DT_{50} was assumed to be 1000 days (since most of the applied diquat will not adsorb to soil), the peak concentration after 20 years would be 11.7 mg ac/kg ds [34]. This is still expected to overestimate the actual concentration that could be achieved as it uses a conservative estimate of the degradation of diquat in solution, does not account for any dissipation of residues due to environmental transport, and does not include a foliar interception factor.

Using the revised soil concentration (11.7 mg ac/kg ds), the risk quotient (RQ) would be 2.4 (with a default slope of 8%) or 0.70 (with a slope of 3% for dryland cropping situations). Whilst the risk is not fully resolved for an 8% slope further consideration of the risk at higher tier is not considered to be required, and an acceptable risk is concluded. This conclusion is based on consideration that the screening stage assessment is inherently conservative (such that it is expected that higher tier assessment would result in an acceptable risk, given the RQ), the assumptions regarding accumulation of diquat in soil are considered conservative, interception has not been accounted for in the exposure estimate, and for the majority of use cases a 3% slope is expected to be more reflective of actual use conditions.

For sediment dwelling organisms, an acceptable risk has not been demonstrated (Table 31). However, the toxicological data (NOEC 11 mg ac/kg ds, Bradley 2013a) are limited in that they reflect the properties of the test system. More specifically, in large part the data reflect the capacity of the test sediment to absorb diquat and this will not necessarily be reflective of other sediments or the modelled exposure – on the basis that diquat strongly absorbed to clay particles will not be biologically available, and higher capacity to absorb diquat will lead to greater concentrations in the bulk sediment but not necessarily more adverse toxicological outcomes. Alternately, the toxicological data can be evaluated based on the concentration in the pore water, on the assumption that the pore water concentration will more reliably reflect the toxicological impact of diquat than the bulk concentration in the

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[33] 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).

[34] i.e. peak concentration of 7.1 mg ac/kg ds after 7 years (DT_{50} 41 years) equivalent to the SAC-WB value for the modelled soil, and a peak concentration of 4.6 mg ac/kg ds after 13 years (DT_{50} 1000 d) for residues in solution. Therefore, the peak total concentration after 20 years is 11.7 mg ac/kg ds (7.1 + 4.6) – this simplistic approach does not account for any losses from the fraction representing the SAC-WB concentration after the initial 7 years of accumulation.

sediment. For the purposes of this assessment the NOEC in terms of the pore water concentration is estimated at 0.014 mg ac/L [35]. This is greater than the RAC for the water phase (i.e. 0.0014 mg ac/L) and the risk would also be considered acceptable for sediment dwelling organisms. Given the limitations of the available information the risk is concluded to be acceptable on this basis.

Table 30: Assessment of risks to non-target aquatic species for aquatic use situations

Scenario	PEC	RAL	RQ
Water injection	1,000 µg ac/L	47 µg ac/L	**21**
One surface spray application (lowest rate)	167 µg ac/L	47 µg ac/L	**3.5**

Water injection PEC is based on target concentration of 1.0 mg ac/L

Surface spray application is based on 250 g ac/ha across whole pond (25% of 1000 g ac/ha) and 15-cm water depth

RAL = regulatory acceptable level for aquatic animals (from Table 28)

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

Table 31: Assessment of runoff risks to aquatic species for terrestrial use situations

Parameter		Sands (clay ≤10%)		10th percentile of all soils	
		DT_{50} 1000 d (default for persistent substances)	DT_{50} 41 years (longest reported for field soil)	DT_{50} 1000 d (default for persistent substances)	DT_{50} 41 years (longest reported for field soil)
Soil					
Exposure rate	(g/ha)	3525	13725	3525	13725
Soil DT_{50}	(d)	1000	14965	1000	14965
K_f	(L/kg)	349	349	62	62

[35] In Bradley (2013a) the mean measured pore water concentrations were <0.0061, 0.014, 0.041, 0.039, and 0.070 mg ac/L for bulk sediment mean measured treatment concentrations of 3.0, 6.4, 11, 23 and 47 mg ac/kg ds, respectively. The mean pore water concentrations (0.041 and 0.039 mg ac/L) at the NOEC and the next highest treatment (11 and 23 mg ac/kg ds, respectively) are essentially the same – significant effects on reproduction were observed at 23 mg ac/kg ds. This can be attributed to higher initial (day 0) but lower long-term (day 14 and 28) pore water concentrations in the NOEC treatment compared to the next highest treatment group. Given the uncertainty regarding the porewater exposure and to ensure a protective assessment, the porewater concentration for the next lowest treatment group has been considered in the risk assessment (porewater NOEC 0.014 mg ac/L).

Parameter		Sands (clay ≤10%)		10th percentile of all soils	
		DT_{50} 1000 d (default for persistent substances)	DT_{50} 41 years (longest reported for field soil)	DT_{50} 1000 d (default for persistent substances)	DT_{50} 41 years (longest reported for field soil)
1/n		0.59	0.59	0.47	0.47
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)	0.00014	0.00037	0.00088	0.0041
slope factor – F	(fraction)	0.26	0.26	0.26	0.26
Runoff	(% applied)	0.0000032	0.0000081	0.000019	0.000089
Water					
PEC	(µg/L)	0.065	0.65	0.40	7.2
RAL	(µg/L)	1.4	1.4	1.4	1.4
Risk quotient	(fraction)	0.046	0.47	0.28	**5.1**
Sediment					
PEC	(mg/kg)	3.3	33	20	367
RAL	(mg/kg)	11	11	11	11
Risk quotient	(fraction)	0.30	**3.0**	**1.9**	**33**

Scenarios are based on annual applications of 1 × 800 g ac/ha for 20 years with no interception and soil DT_{50} of 1000 d or 41 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:

4.7 mg ac/kg ds with DT_{50} of 1000 days

18.3 mg ac/kg ds with DT_{50} of 41 years

Soil DT_{50}, K_f and 1/n from Table 25

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)

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 136759 (from Table 25)

RAL = regulatory acceptable level (from Table 28)

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

6.4.3 Bees

Exposure of bees is expected to be negligible for water injection and surface spray in aquatic areas. Therefore, risks to bees are acceptable for this use pattern.

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 (contact exposure) were acceptable at the highest application rate of 800 g ac/ha (Table 32). Acceptable risks of oral exposure (via pollen and nectar) to foraging bees could only be concluded at rates up to 300 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 rates up to 800 g ac/ha. No protection statement is required.

Table 32: Screening level assessment of risks to bees

Life stage	Scenario	Exposure	Rate (g ac/ha)	Predicted total dose (µg ac/bee)	RAL (µg ac/bee)	RQ
Screening level assessment (pollen & nectar EEC (mg/kg) = rate × 98 / 1000)						
Adults	Aquatic areas (surface spray)	Acute contact	2000	4.8	42	0.11
		Acute oral	2000	57	8.8	6.5
	Desiccation or general weed control	Acute contact	800	1.9	42	0.046
		Acute oral	800	23	8.8	2.6
			600	17	8.8	2.0
			560	16	8.8	1.8
			368	11	8.8	1.2
			300	8.6	8.8	0.98
Refined assessment (pollen EEC (mg/kg) = rate × 52 / 1000 + nectar EEC (mg/kg) = rate × 11 / 1000)						
Adults	Desiccation or general weed control	Acute oral	800	2.6	8.8	0.29

Screening level pollen & 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 dose (from Table 28)
RQ = risk quotient = predicted total dose/RAL, where acceptable RQ ≤1

6.4.4 Other arthropod species

Exposure of other terrestrial arthropod species to diquat is considered to be negligible following application to aquatic areas. Therefore, risks of diquat to other terrestrial arthropods are acceptable for aquatic use situations.

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 diquat, 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. Risks to ground-dwelling arthropods are acceptable for all desiccation and general weed control scenarios; however, acceptable risks to foliar-dwelling arthropods could not be concluded for any of these scenarios. Therefore, the following protection statement is recommended for products used for pre-harvest crop desiccation or general weed control.

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

Table 33: Assessment of risks to other non-target arthropods

Scenario	Group	Exposure	Rate (g/ha)	RAL (g/ha)	RQ
Worst-case (1× 800 g ac/ha)	Foliar arthropods	Contact	800	4.1	**195**
	Ground arthropods	Contact	800	1 000	0.80
Best-case (1× 140 g ac/ha)	Foliar arthropods	Contact	140	4.1	**34**
	Ground arthropods	Contact	140	1 000	0.14

RAL = regulatory acceptable level (from Table 28)
RQ = risk quotient = PEC / RAL, where acceptable RQ ≤1

6.4.5 Soil organisms

Exposure of soil organisms to diquat is considered negligible following application to aquatic areas. Therefore, risks of diquat to soil organisms are acceptable for aquatic use situations.

For desiccation and general weed control uses, 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

800 g ac/ha with no foliar interception, the peak concentration was predicted to be 4.7 mg ac/kg dry soil (acute exposure scenario), while the steady state concentration was predicted to be 3.7 mg ac/kg dry soil (chronic exposure scenario). Risks to soil organisms were determined to be acceptable under this worst-case scenario (Table 34), and no protection statements are therefore required.

Table 34: 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	800	4.7	9.4	0.50
	Chronic	800	3.7	9.4	0.39
Micro-organisms	Chronic	800	3.7	500	0.01

Worst-case scenario based on 1× 800 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

Chronic PEC is based on steady state concentration predicted in top 5-cm

RAL = regulatory acceptable level (from Table 28)

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

6.4.6 Non-target terrestrial plants

As indicated in Table 28, the RAL for the spray drift assessment is 15 g ac/ha for the protection of vegetation areas. Risks of spray drift are addressed separately, as needed.

6.5 Recommendations

Uses supported from the viewpoint of environmental safety are listed in Table 35 with the required protection statements and restraints. Uses that are not supported from the viewpoint of environmental safety are listed in Table 36.

Table 35: Supported uses of diquat from the viewpoint of environmental safety

Product type	Situation	Protection statements and restraints
n/a	All supported situations	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. However, the use of this product as directed is not expected to have adverse effects on birds.

Product type	Situation	Protection statements and restraints
		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.
Diquat products	Aquatic areas (boomspray, surface spray and injection below surface)	DO NOT apply to water bodies from which the product may contaminate natural aquatic areas.
	General weed control: pasture at rates up to 188 g ac/ha; row crops, market gardens, vegetables at rates up to 283 g ac/ha Pre-harvest crop desiccation: cotton, poppies, sugarcane General weed control: asparagus, hops, infested areas, lucerne, oil seed poppies, oats, wheat	No additional protection statements or restraints required

Table 36: Uses of diquat not supported from the viewpoint of environmental safety

Product type	Situation	Basis
Diquat products	Pre-harvest crop desiccation: rice, sorghum at rates >122 g ac/ha; legume seed crops, lupins, potatoes, pulses, sweet potatoes at rates >278 g ac/ha; canola, linseed at rates >283 g ac/ha; sunflower at rates >323 g ac/ha General weed control: wheat, winter cereals at rates >122 g ac/ha; market gardens, row crops, vegetables at rates >283 g ac/ha	Unacceptable risk to birds
	General weed control in orchards (including bananas, citrus, pome fruit, stone fruit, tree nuts tropical fruit edible/inedible peel) and vineyards where there is an obligatory tank mix with paraquat	Unacceptable risk to mammals
	General weed control: pasture at rates >188 g ac/ha	Unacceptable risk to mammals
	General weed control: pasture at rates >230 g ac/ha	Unacceptable risk to birds and mammals

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 are summarised in Table 37, which is the maximum amount of spray drift exposure that is not expected to cause undue harm to sensitive areas.

Table 37: Regulatory acceptable levels of diquat resulting from spray drift

Area considered	Regulatory acceptable level
Natural aquatic areas	1.4 µg ac/L
Pollinator areas	17,500 g ac/ha
Vegetation areas	15 g ac/ha
Bystander areas	3.87 g ac/ha
Livestock areas	100 mg/kg

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

Based on the acceptable uses, the following spray drift restraints and downwind buffer zones would be required for application of diquat products at the rates listed below.

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 38: Diquat – buffer zones for boom sprayers

Diquat–buffer zones for boom sprayers (metres; MEDIUM droplet size)						
Application rate	Boom height above the target canopy	Bystander areas	Natural aquatic areas	Pollinator areas	Vegetation areas	Livestock areas
2 kg ac/ha or lower	0.5 m or lower	110	275	0	35	0
	1.0 m or lower	Not supported				
1 kg ac/ha or lower	0.5 m or lower	50	110	0	20	0
	1.0 m or lower	160	350	0	60	0
800 g ac/ha or lower	0.5 m or lower	40	85	0	20	0
	1.0 m or lower	130	250	0	55	0
600 g ac/ha or lower	0.5 m or lower	35	65	0	10	0
	1.0 m or lower	100	180	0	45	0
300 g ac/ha or lower	0.5 m or lower	20	40	0	5	0
	1.0 m or lower	60	110	0	25	0
140 g ac/ha or lower	0.5 m or lower	5	20	0	0	0
	1.0 m or lower	35	60	0	15	0
80 g ac/ha or lower	0.5 m or lower	0	10	0	0	0
	1.0 m or lower	20	10	0	10	0

DO NOT apply by a vertical sprayer.

DO NOT apply by aircraft unless the following requirements are met:

– Spray droplets not smaller than a MEDIUM spray droplet size category.
– For maximum release heights above the target canopy of 3m or 25% of wingspan or 25% of rotor diameter whichever is the greatest, minimum distances between the application site and downwind sensitive areas (see 'Mandatory buffer zones' section of the following table titled 'Buffer zones for aircraft') are observed.

Table 39: Diquat – buffer zones for aircraft (metres; MEDIUM droplet size)

Diquat–buffer zones for aircraft (metres; MEDIUM droplet size)					
Type of aircraft (rate)	Bystander areas	Natural aquatic areas	Pollinator areas	Vegetation areas	Livestock areas
Fixed-wing (280 g ac/ha)	275	525	0	100	0
Fixed-wing (150 g ac/ha)	170	275	0	65	0
Helicopter (280 g ac/ha)	180	300	0	65	0
Helicopter (150 g ac/ha)	120	190	0	50	0

8 Storage and disposal

8.1 Storage

Products containing diquat alone require the following storage statement.

> **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.**

Appendices

Appendix A – Summary of assessment outcomes

Table 40: Risk assessment outcomes for products containing diquat

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome [36]	Overall Outcome
Cotton (short stapled varieties only)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	Supported	Not supported	Supported	**Not supported**
Cotton (short stapled varieties only)	Pre-harvest crop desiccation	140 g ac/ha plus 16.5 L/ha Leafex* (boomspray)	Supported	Not supported		**Not supported**
Dry Beans (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**
Dry Peas (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**
Lentils (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**
Chickpeas (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**
Faba Beans (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**
Linseed (Oilseeds)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (7 day WHP)		**Not supported**
Lupins (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**

[36] See Table 10 in Diquat Review Technical Report for PPE and work rate restrictions. Closed mixing/loading required

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome [36]	Overall Outcome
Mung beans (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)	Supported	**Not supported**
Perennial legume seed crops (Lucerne)	Pre-harvest crop desiccation	300-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day harvest, 1 day grazing WHP)		**Not supported**
Perennial legume seed crops (Red clover)	Pre-harvest crop desiccation	300-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day harvest, 1 day grazing WHP)		**Not supported**
Perennial legume seed crops (White clover)	Pre-harvest crop desiccation	300-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day harvest, 1 day grazing WHP)		**Not supported**
Pigeon peas (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**
Poppies	Pre-harvest crop desiccation	600-800 g ac/ha (boomspray)	Supported up to 800 g ac/ha (WOE argument, Tas only)	Supported (2 day WHP)	Supported	Supported
Potato (Haulm desiccation)	Pre-harvest crop desiccation	600-800 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (7 day WHP)	Supported	**Not supported**
Potato (Ground stored–preharvest weed control)	Pre-harvest crop desiccation	300 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (7 day WHP)		**Not supported**
Canola (Rape; Oilseeds)	Pre-harvest crop desiccation	300-600 g ac/ha (boomspray)	**Not supported** (max. 283 g ac/ha)	Supported (7 day WHP)		**Not supported**
Rice	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 122 g ac/ha)	Supported – pre-emergent only		**Not supported**
Sorghum (Cereals)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 122 g ac/ha)	Supported – crop establishment only		**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 [36]	Overall Outcome
Soya Beans (Pulses)	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (4 day WHP)		**Not supported**
Sugar Cane	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	Supported (up to 600 g ac/ha)	**Not supported**	Supported	**Not supported**
Sugar Cane	Pre-harvest crop desiccation	200 mL/200L water (high volume hand spraying)	Supported	**Not supported**	Supported	**Not supported**
Sunflower	Pre-harvest crop desiccation	400-600 g ac/ha (boomspray)	**Not supported** (max. 323 g ac/ha)	Supported (7 day WHP)	Supported	**Not supported**
Sweet potatoes	Pre-harvest crop desiccation	600-800 g ac/ha (boomspray)	**Not supported** (max. 278 g ac/ha)	Supported (14 day WHP)	**Not supported**	**Not supported**
General Weed Control- specific weeds listed below						
Aquatic areas (farm dams and artificial water bodies only)	Duck weeds, red azolla, water hyacinth, salvinia, marsilea, water lilies, water lettuce	1-2 kg ac/ha (boomspray)	Supported (DO NOT apply to or allow contamination of natural aquatic areas)	Supported (10 day no human, livestock or irrigation use)	Supported	Supported
		80 g ac plus 150 mL Agral wetter per 100L water (hand spray -small areas)	Supported (DO NOT apply to or allow contamination of natural aquatic areas)	Supported (10 day no human, livestock or irrigation use)	Supported	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 [36]	Overall Outcome
	Cattail and Pond Weeds	1 kg ac/5ML water (Injection below surface, Surface spray)	Supported (DO NOT apply to or allow contamination of natural aquatic areas)	Supported (10 day no human, livestock or irrigation use)	Supported	Supported
Asparagus (prior to spear emergence)	Broadleaf weeds (prior to spear emergence)	280 g ac/ha (boomspray)	Supported	Supported	Supported	Supported
Hops (apply prior to emerging from winter dormancy)	Annual broadleaf and grass weeds	140-280 g ac/ha (directed Inter-row spray)	Supported	Supported	Supported	Supported
Infested areas	Cotton Thistle (*Onopordum acanthium*)	60 g ac/ha (Spot spray)	Supported (Tas only)	Supported	Supported	Supported
	Saffron Thistle	560 g ac/ha (Boomspray, Spot spray)	Supported (change from proposed, WOE)	Supported	Supported	Supported
Lucerne (grazed before spraying)	Capeweed and Erodium spp.	70 g ac/ha (Early Autumn – Boomspray)	Supported up to 140 g ac/ha per season	Supported	Supported	Supported with rate restriction37
		140 g ac/ha (late winter – Boomspray)				
Oil seed poppies	General weed control	60-300 g ac/ha (boomspray)	Supported up to 283 g ac/ha per season	Supported	Supported	Supported with rate restriction37

Crop Use or Situation	Weeds controlled	Rate (Application Method)	Environment Risk Assessment Outcome	Residues and Trade Risk Assessment Outcome	Human Health Risk Assessment Outcome [36]	Overall Outcome
Orchards (including bananas) and Vineyards: Citrus, Grapes, Pome fruit, Stone fruit, Tree nuts, Tropical fruit (edible peel), Tropical fruit (inedible peel, except pineapple)	Capeweed	300 g ac/ha (Directed spray, inter-row spray, Butt spray) plus 400 g ac/ha paraquat	Supported for diquat alone. **Not supported** for obligatory paraquat tank mix (max rate supported 54 g ac/ha paraquat)	Supported	Supported	**Not supported** on the basis of obligatory paraquat tank mix
Pasture renovation and establishment (apply after heavy grazing)	Capeweed and Erodium spp. (Storksbill)	150-300 g ac/ha (boomspray)	Supported up to 188 g ac/ha	Supported up to 188 g ac/ha (1 day grazing WHP)	Supported	Supported with rate restriction [37]
	Barley grass, brome grass, silver grass and sweet vernal grass	150-300 g ac/ha (boomspray) plus 250-400 g ac/ha paraquat	Diquat supported up to 188 g ac/ha but paraquat not supported (max 231 g ac/ha)			**Not supported** on the basis of obligatory paraquat tank mix
	Capeweed (very young seedling, 2-3 leaf stage only)	70 g ac/ha (boomspray)	Supported	Supported (1 day grazing WHP)		Supported

[37] 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 [36]	Overall Outcome
Berries and other small fruit (except grapes) [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported	Supported	Supported
Berries and other small fruit (except grapes) [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Supported	Supported (excluding backpack sprayer)	**Not supported**
Brassica vegetables: broccoli, head cabbages, cauliflower and Chinese cabbage (type Pe-tsai) [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported for specific listed crops only	Supported	Supported
Brassica vegetables: broccoli, head cabbages, cauliflower and Chinese cabbage (type Pe-tsai) [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Supported for specific listed crops only	Supported (excluding backpack sprayer)	**Not supported**
Bulb vegetables: bulb onions [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported	Supported	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 [36]	Overall Outcome
Bulb vegetables: bulb onions [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Not supported (max 283 g ac/ha)	Supported (excluding backpack sprayer)	**Not supported**
Bulb vegetables: other than bulb onions [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported	Supported	Supported
Bulb vegetables: other than bulb onions [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Not supported	Supported (excluding backpack sprayer)	**Not supported**
Fruiting Vegetables: cucurbits [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported (cucumber only)	Supported	Supported
Fruiting Vegetables: cucurbits [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Supported (cucumber only)	Supported (excluding backpack sprayer)	**Not supported**
Fruiting Vegetables: other than cucurbits [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported	Supported	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 [36]	Overall Outcome
Fruiting Vegetables: other than cucurbits [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Supported	Supported (excluding backpack sprayer)	**Not supported**
Leafy vegetables [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported	Supported	Supported
Leafy vegetables [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Supported	Supported (excluding backpack sprayer)	**Not supported**
Legume vegetables [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported	Supported	Supported
Legume vegetables [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Supported	Supported (excluding backpack sprayer)	**Not supported**
Pineapple [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Not supported	Supported (excluding backpack sprayer)	**Not supported**
Pineapple [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Not supported	Supported (excluding backpack sprayer)	**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 [36]	Overall Outcome
Root and tuber vegetables [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported	Supported	Supported
Root and tuber vegetables [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Not supported (max. 283 g ac/ha)	Supported	Supported (excluding backpack sprayer)	**Not supported**
Stalk and stem vegetables, including asparagus [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Supported for asparagus only	Supported	Supported
Stalk and stem vegetables, including asparagus [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	**Not supported** (max. 283 g ac/ha)	Supported for asparagus only	Supported (excluding backpack sprayer)	**Not supported**
Herbs and spices [Row crops, vegetables and market gardens]	Broadleaf weeds (seedling weeds)	280 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	Supported	Not supported	Supported	**Not supported**
Herbs and spices [Row crops, vegetables and market gardens]	Broadleaf weeds (mature weeds)	560 or 800 g ac/ha (Boomspray, handwand, inter-row spray (shielded))	**Not supported** (max. 283 g ac/ha)	Not supported	Supported (excluding backpack sprayer)	**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 [36]	Overall Outcome
Wheat, Oats (up to early tillering)	Capeweed	110-140 g ac/ha (Boomspray)	Supported (max 122 g ac/ha per season)	Supported (1 day grazing WHP)	Supported	Supported with rate restriction[37]
Wheat	Pre-harvest weed control	400-600 g ac/ha (Boomspray)	**Not supported** (max. 122 g ac/ha)	Supported (1 day grazing WHP)	Supported	**Not supported**
Wheat	Suppression of wild radish (GS 10–12)	140 g ac/ha (boomspray)	**Not supported** (max. 122 g ac/ha)	Supported (1 day grazing WHP)	Supported	**Not supported**
Winter Cereals (Barley, oats, rye, triticale and wheat)	Pre-harvest weed control	200-600 g ac/ha (boomspray)	**Not supported** (max. 122 g ac/ha)	Supported	Supported	**Not supported**

Appendix B – Listing of environmental endpoints

Table 41: Diquat – dissipation in animal food items

Substance	Matrix	Result		Reference
Diquat	Insects	Beetles:	DT_{50} 2.2 d	Jutsum 2011
		Mixed:	DT_{50} 2.3 d	Edwards et al. 1991
		Geomean DT_{50} 2.2 d		
	Foliage	Lettuce:	DT_{50} 1.4 d	Kennedy 1984, Massey 1987(c)
		AT oilseed rape: n-FR oilseed rape:	DT_{50} 1.7 d DT_{50} 2.4 d	Langridge 2011a
		ES oilseed rape: IT oilseed rape: s-FR oilseed rape:	DT_{50} 1.7 d DT_{50} 2.8 d DT_{50} 3.0 d	Langridge 2011b
		Corn sowthistle: Sedges: Climbing false buckwheat: Reed canary grass:	DT_{50} 2.1 d DT_{50} 1.8 d DT_{50} 1.4 d DT_{50} 1.0 d	Edwards et al. 1991
		Geomean DT_{50} 1.8 d		
	Seeds	Sedges: Reed canary grass: Lentils:	DT_{50} 17 d DT_{50} 10 d DT_{50} 2.9 d	Edwards et al. 1991
		Geomean DT_{50} 7.9 d		

Table 42: Diquat – fate and behaviour in soil

Substance	Study	Result		Reference
Diquat	Soil photolysis	Moist soil: Dry soil: 0.2% mineralisation after 30 d 1.5% bound residues after 30 d	DT_{50} 36 d DT_{50} 197 d	Dixon & Gilbert 2012a

Substance	Study	Result				Reference
		Max 9.9% TOPPS				
Diquat	Aerobic laboratory soil	Sandy loam: stable				Johnston 1988a
		Loam:	DT_{50} 598 d			Dixon 2012a
		Sandy clay loam:	DT_{50} 2330 d			
		Silty clay:	DT_{50} 6174 d			
		Sandy clay loam:	DT_{50} 3516 d			
		Sandy clay loam:	DT_{50} 976 d			Mônego 2006a
		Clay:	DT_{50} 290 d			
		Sand:	DT_{50} 468 d			
		Sandy loam:	DT_{50} 568 d			
		Geomean DT_{50} 1108 d				
		<5% mineralisation after 119-120 d				
		0.4-16% bound residues after 119-120 d				
	Anaerobic laboratory soil	Loam:	DT_{50} 1019 d			Dixon 2012b
		Sandy clay loam:	DT_{50} 3642 d			
		Silty clay:	DT_{50} 1431 d			
		Sandy clay loam:	DT_{50} 12743 d			
		Geomean DT_{50} 2868 d				
		<5% mineralisation after 120 d				
		0.4-9.5% bound residues after 120 d				
	Adsorption/ desorption	Soil	% clay	Kf	1/n	
		Loam	12	144	0.59	Dixon & Gilbert 2012b
		Sandy clay loam	25	9011	0.89	
		Silty clay	39	12932	0.93	
		Sandy loam	19	70308	1.06	
		Sandy clay loam	46	507	0.56	Mônego 2005
		Clay	61	1519	0.69	
		Sand	10	910	0.68	
		Sandy loam	21	484	0.59	

Substance	Study	Result	Reference
		Sand 2 36 0.40	Pack 1987
		Sand 4 42 0.45	
		Sandy clay loam 21 4895 0.94	
		Loam 9 10740 1.00	
		Sandy loam 13 1882 0.75	
		Geomean Kf 349 mL/g, 1/n 0.59 for ≤10% clay	
		Geomean Kf 2517 mL/g, 1/n 0.76 for >10% clay	
	Terrestrial field dissipation	UK SAC-WB 50%: DT_{50} 41 years	Cole et al. 1991, Dyson & Chapman 1991
		UK SAC-WB 110%: DT_{50} 11 years	
		UK SAC-WB 400%: DT_{50} 14 years	
		USA SAC-WB 50%: DT_{50} 3.6 years	Dyson et al. 1995a, 1995b
		USA SAC-WB 100%: DT_{50} 3.0 years	
		USA SAC-WB 200%: DT_{50} 1.2 years	
		USA potato:stable	Fujie 1991
TOPPS	Aerobic laboratory soil	Loam: DT_{50} 28 d	Dixon & Dove 2012, Patterson 2012
		Sandy clay loam: DT_{50} 750 d	
		Silty clay: DT_{50} 159 d	
		Loam: DT_{50} 757 d	
		Geomean DT_{50} 224 d	
TOPPS	Adsorption/ desorption	Soil %OC Kf 1/n	Dixon & Gilbert 2012c
		Loam 2.1 3.4 0.72	
		Sandy clay loam 2.3 43 0.74	
		Silty clay 0.8 52 0.54	
		Loam 1.5 207 0.56	
		Sandy loam 2.5 430 0.57	
		Mean Kf 147 mL/g, 1/n 0.63	

Table 43: Diquat – fate and behaviour in water and sediment

Substance	Study	Result	Reference
Diquat	Hydrolysis	pH 4, 50°C: stable pH 7, 50°C: stable	Dixon & Alderman 2012, White 2010b

Substance	Study	Result	Reference
		pH 9, 50°C: stable	
	Aqueous photolysis	DT_{50} 11 d (pH 7 buffer, mid-European spring sunlight)	Moffatt 1993
		DT_{50} 10 d (natural water, spring sunlight at 35°N)	Dean 2000
		DT_{50} 2.0 d (natural water, summer sunlight at 40°N) 3.8% mineralisation after 3d Max 23% TOPPS Max 12% AQ1	Oliver & Webb 2005
	Degradation in aerobic water/sediment	Cal Abbey water DT_{50} 0.45 d Cal Abbey system DT_{50} 1272 d Swiss L water DT_{50} 0.32 d Swiss L system DT_{50} 1024 d	Ford et al. 2012
		BR fine water DT_{50} 0.033 d BR coarse water DT_{50} 0.046 d	Mônego 2006b
		Florida system stable	Cranor & Daly 1988
		Geomean DT_{50} 0.12 d in water Geomean DT_{50} 1141 d in system	
		Max 100% diquat in sediment 0.32% mineralisation after 90-100 d 1.4-2.8% bound residues after 90-100 d	
	Degradation in anaerobic water/sediment	Cal Abbey water DT_{50} 0.72 d Swiss L water DT_{50} 0.85 d Geomean DT_{50} 0.78 d	Ford et al. 2012
		Cal Abbey system DT_{50} 2028 d Swiss L system DT_{50} 1794 d Geomean DT_{50} 1907 d	
		Florida system stable	Johnston 1988b
		Max 100% diquat in sediment <0.05% mineralisation after 100 d	

Substance	Study	Result				Reference
		1.7-2.9% bound residues after 100 d				
	Adsorption/ desorption	Sediment	%OC	Kf	1/n	
		Fine	4.9	400809	1.41	Mônego 2005
		Coarse	0.7	9452	1.02	
		Sand	0.7	15	0.52	Pack 1987
		Mean Kf 136759 mL/g, 1/n 0.98				
	Aquatic field dissipation	DT_{50} 0.50 d in Florida pond water				Fujie1988(d)

Table 44: Diquat – fate and behaviour in air

Substance	Study	Result	Reference
Diquat	Photochemical oxidative degradation	DT_{50} 5.5 h	Hayes 2001

Table 45: Diquat – monitoring data

Substance	Medium	Result	Reference
Diquat	Insects	Max 5.0 mg/kg in beetles following cereal stubble application at 1000 g ac/ha	Jutsum 2011
		Max 185 mg/kg in insects following lentil application at 550 g ac/ha	Edwards et al. 1991
	Foliage	Max 0.23 mg/kg in lettuce following interrow application at 750 g ac/ha	Kennedy 1984
		Max 0.91 mg/kg in lettuce following interrow application at 960 g ac/ha	Massey 1987(c)
		Max 17 mg/kg in oilseed rape following application at BBCH 87-89 at 600 g ac/ha	Langridge 2011a, 2011b
		Max 56 mg/kg in various seeds following lentil application at 550 g ac/ha	Edwards et al. 1991
	Soil	Max 0.86 mg/kg following long-term use as crop desiccant at 300-1400 g ac/ha (46 trials)	Devine 2004

Substance	Medium	Result	Reference
		Max 0.11 mg/kg, average 0.03 mg/kg following long-term use as crop desiccant at 500-1000 g ac/ha; average 25% carry over (39 trials)	Anderson & Earl 1996

Table 46: Diquat – effects on terrestrial vertebrates

Test substance	Group	Exposure	Species	Toxicity value [38]	Reference
Diquat	Mammals	Acute	*Rattus norvegicus*	LD_{50} 120 mg ac/kg bw	Rittenhouse 1979
				LD_{50} 218 mg ac/kg bw	McCall & Robinson 1990
		Chronic	*Rattus norvegicus*	NOAEL 4.0 mg ac/kg bw/d	Hodge 1990
	Birds	Acute	*Anas platyrhynchos*	LD_{50} 71 mg ac/kg bw	Fink et al. 1982
			Taeniopygia guttata	LD_{50} 31 mg ac/kg bw	Hubbard 2013
			Perdix perdix	LD_{50} 158 mg ac/kg bw	Roberts & Fairley 1980
			Geomean LD_{50} 70 mg ac/kg bw		
		Dietary	*Anas platyrhynchos*	LC_{50} >2677 mg ac/kg feed	Hill et al. 1975
			Colinus virginianus	LC_{50} 1570 mg ac/kg feed	
			Coturnix coturnix japonica	LC_{50} 721 mg ac/kg feed	
			Phasianus colchicus	LC_{50} 2004 mg ac/kg feed	
		Chronic	*Colinus virginianus*	NOEL 10 mg ac/kg bw/d	Beavers & Fink 1982
			Anas platyrhynchos	NOEL 3.2 mg ac/kg bw/d	Temple et al. 2004a, 2004b

[38] All toxicity values are reported in terms of the active constituent, which is defined as the diquat cation

Table 47: Diquat – laboratory studies on aquatic species

Substance	Group	Exposure	Species	Toxicity value	Reference
Diquat	Vertebrates	Acute	*Sander vitreus* *Micropterus dolomieu* *Micropterus salmoides*	LC_{50} 0.75 mg ac/L LC_{50} 3.9 mg ac/L LC_{50} 4.9 mg ac/L	Paul et al. 1994
			Cyprinodon variegatus	LC_{50} 49 mg ac/L	Nicholson 1987
		Chronic	*Pimephales promelas*	NOEC 0.12 mg ac/L	Surprenant 1987a
			Cyprinodon variegatus	NOEC 3.0 mg ac/L	Minderhout 2012
	Invertebrates	Acute	*Hyalella azteca*	LC_{50} 0.084 mg ac/L	Bender 2006a
			Americamysis bahia	LC_{50} 0.42 mg ac/L	Hoberg 1987
			Daphnia magna	EC_{50} 2.5 mg ac/L	Volz 2004
			Crassostrea virginica	EC_{50} 141 mg ac/L	Dionne 1987
	Invertebrates	Chronic	*Daphnia magna*	NOEC 0.036 mg ac/L	Surprenant 1987b
			Americamysis bahia	NOEC 0.052 mg ac/L	Claude et al. 2013
			Lymnaea stagnalis	NOEC 0.0011 mg ac/L	Ducrot et al. 2010
	Sediment-dwellers	Acute	*Leptocheirus plumulosus*	LC_{50} >110 mg ac/kg ds	Bradley 2015
		Chronic	*Hyallela azteca*	NOEC 11 mg ac/kg ds	Bradley 2013a
			Chironomus dilutus	NOEC 37 mg ac/kg ds	Bradley 2013b
			Chironomus riparius	NOEC 100 mg ac/kg ds	Ashwell 1999
	Algae	Chronic	*Navicula pelliculosa*	E_rC_{50} 0.0012 mg ac/L	Smyth et al. 1998a
			Nitzschia palea *Achnanthidium minutissimum* *Raphidocelis subcapitata* *Pseudanabaena foetida* *Synechococcus leopoliensis*	EC_{50} 0.0052 mg ac/L EC_{50} 0.0073 mg ac/L EC_{50} 0.055 mg ac/L EC_{50} 0.23 mg ac/L EC_{50} 0.29 mg ac/L	Nagai 2019

Substance	Group	Exposure	Species	Toxicity value	Reference
			Fistulifera pelliculosa	EC_{50} 0.33 mg ac/L	
			Desmodesmus subspicatus	EC_{50} 3.2 mg ac/L	
			Anabaena flos-aquae	E_rC_{50} 0.025 mg ac/L	Smyth et al. 1998b
			Skeletonema costatum	E_rC_{50} 12 mg ac/L	Smyth et al. 1998c
	Aquatic plants	Chronic	*Lemna gibba*	EC_{50} 0.0032 mg ac/L	Magor & Shillabeer 2001
TOPPS	Invertebrates	Acute	*Daphnia magna*	EC_{50} >110 mg/L	Liedtke 2011a
	Algae	Chronic	*P. subcapitata*	E_rC_{50} >110 mg/L	Liedtke 2011b
	Aquatic plants	Chronic	*Lemna gibba*	E_rC_{50} >111 mg/L	Liedtke 2011c

Table 48: Diquat – microcosm studies on aquatic species

Substance	Group	Exposure	Species	ER_{50} or EC_{50}	Reference
EC 240 g/L	Aquatic plants	Spray application	*Spirodela punctata*	3.5 g ac/ha	Bellet 1990a
			Eichhornia crassipes	26 g ac/ha	
			Azolla caroliniana	48 g ac/ha	
			Pistia stratiotes	125 g ac/ha	
			Pteridium aquilinum	336 g ac/ha	
			Brasenia schreberi	3504 g ac/ha	
			Panicum repens	3552 g ac/ha	
			Paspalum notatum	14064 g ac/ha	
		Water-injection application	*Spirodela punctata*	3.1 µg ac/L	Bellet 1990a
			Hydrilla verticillate	60 µg ac/L	
			Azolla caroliniana	80 µg ac/L	
			Eichhornia crassipes	90 µg ac/L	
			Pistia stratiotes	90 µg ac/L	
			Panicum repens	15900 µg ac/L	

Table 49: Diquat – effects on bees

Test substance	Species	Life stage	Exposure	Toxicity value	Reference
SL 200 g/L	Apis mellifera	Adult	Acute contact	LD50 105 µg ac/bee	Gough et al. 1987
			Acute oral	LD50 22 µg ac/bee	Gough et al. 1987

Table 50: Diquat – effects on other non-target arthropods

Test substance	Group	Species	Test substrate	Toxicity value	Reference
SL 200 g/L	Predatory arthropods	*Typhlodromus pyri*	Glass plate	LR_{50} 2.9 g ac/ha	Austin & Elcock 1999a
			Bean leaf disc	LR_{50} 4.1 g ac/ha ER_{50} >1.0 g ac/ha	Austin & Elcock 1999b
	Predatory arthropods	*Poecilus melanarius*	Loamy sand	LR_{50} >1600 g ac/ha ER_{50} >1600 g ac/ha	Gough et al. 1991
		Pardosa spp.	Loamy sand	LR_{50} >1600 g ac/ha ER_{50} >1600 g ac/ha	Gough et al. 1991
	Parasitic arthropods	*Aphidius rhopalosiphi*	Glass plate	LR_{50} 3.2 g ac/ha	Austin 1999a
			Barley plants	LR_{50} 758 g ac/ha	Austin 1999b
		Aleochara bilineata	Artificial soil	LR_{50} >1000 g ac/ha ER_{50} >1000 g ac/ha	Beech 1997

Table 51: Diquat – laboratory studies on soil organisms

Test substance	Group	Exposure	Species/process	Toxicity value	Reference
Diquat	Macro-organisms	Acute	*Eisenia fetida*	LC_{50} 94 mg ac/kg ds	Bender 2006b
		Chronic	*Eisenia fetida*	NOEC 37 mg ac/kg ds	Friedrich 2007a
			Folsomia candida	NOEC 9.4 mg ac/kg ds	Friedrich 2007b
			Hypoaspis aculeifer	NOEC 50 mg ac/kg ds	Schultz 2007a
	Micro-organisms	Chronic	Nitrification	NOEC 3.4 mg ac/kg ds	Bender 2006c

Test substance	Group	Exposure	Species/process	Toxicity value	Reference
				NOEC 500 mg ac/kg ds	Schultz 2007b
TOPPS	Macro-organisms	Chronic	*Eisenia fetida*	NOEC 80 mg/kg ds	Friedrich 2011a
			Folsomia candida	NOEC 144 mg/kg ds	Friedrich 2011b
			Hypoaspis aculeifer	NOEC 320 mg/kg ds	Schultz 2011a
	Micro-organisms	Chronic	Nitrification	NOEC 160 mg/kg ds	Schultz 2011b

Table 52: Diquat – field studies on soil organisms

Substance	Exposure	Effect	Reference
Diquat	90, 198 and 720 kg ac/ha (50, 110 and 400% SAC) Incorporated to 150 mm	Earthworm numbers and weight were all reduced at 1 year; however, no observed differences after 6 years	Edwards 1980
	15, 33 and 120 kg ac/ha (50, 110 and 400% SAC) Incorporated to 25 mm		
	112 kg ac/ha No incorporation	No impact on earthworm numbers or weight at 5 months, 1 year or 2 years. SAC not reported.	Wilkinson & Edwards 1993
	1700 kg ac/ha Incorporated to 100 mm		
	1.0 kg ac/ha annually (plateau 22.5 kg ac/ha)	No significant impact on straw decomposition up to 9 months after litterbag burial in treated soil. SAC not reported.	Mack 2010

Table 53: Diquat – laboratory studies on non-target terrestrial plants

Test substance	Exposure	Species	ER25	ER50	Reference
SL 200 g/L	Pre-emergent	*Allium cepa*	>8400 g ac/ha	>8400 g ac/ha	Shilling 1987
		Cassia obtusifolia	>8400 g ac/ha	>8400 g ac/ha	
		Datura stramonium	>8400 g ac/ha	>8400 g ac/ha	
		Echinochloa crusgalli	>8400 g ac/ha	>8400 g ac/ha	
		Glycine max	>8400 g ac/ha	>8400 g ac/ha	

Test substance	Exposure	Species	ER25	ER50	Reference
		Helianthus annuus	>8400 g ac/ha	>8400 g ac/ha	
		Ipomoea hederacea	>8400 g ac/ha	>8400 g ac/ha	
		Secale cereale	>8400 g ac/ha	>8400 g ac/ha	
		Solanum tuberosum	>8400 g ac/ha	>8400 g ac/ha	
		Zea mays	>8400 g ac/ha	>8400 g ac/ha	
		Zea mays	24578 g ac/ha	>75000 g ac/ha	Balluff 2006
		Helianthus annuus	34898 g ac/ha	>75000 g ac/ha	
		Brassica napus	>22500 g ac/ha	>75000 g ac/ha	
		Triticum aestivum	>75000 g ac/ha	>75000 g ac/ha	
	Pre-emergent	*Zea mays*	30900 g ac/ha	48075 g ac/ha	Peterek 2009
	28d aged residues	*Helianthus annuus*	62100 g ac/ha	77700 g ac/ha	
	Post-emergent	*Brassica oleracea*	7.3 g ac/ha	15 g ac/ha	Martin 2013
		Beta vulgaris	9.6 g ac/ha	38 g ac/ha	
		Helianthus annuus	11 g ac/ha	47 g ac/ha	
		Daucus carota	25 g ac/ha	53 g ac/ha	
		Brassica napus	17 g ac/ha	57 g ac/ha	
		Glycine max	18 g ac/ha	257 g ac/ha	
		Zea mays	125 g ac/ha	419 g ac/ha	
		Allium cepa	256 g ac/ha	425 g ac/ha	
		Lolium perenne	287 g ac/ha	445 g ac/ha	
		Avena sativa	>500 g ac/ha	>500 g ac/ha	
		Zea mays	44 g ac/ha	65 g ac/ha	Porch & Krueger 1999
		Triticum aestivum	215 g ac/ha	379 g ac/ha	

Table 54: Diquat – field studies on non-target terrestrial plants (post-emergent exposure)

Test substance	Location	Species	ER25	ER50	Reference
SL 240 g/L	Florida	*Helianthus annuus*	19 g ac/ha	50 g ac/ha	Bellet 1990b
		Glycine max	7.2 g ac/ha	53 g ac/ha	
		Gossypium hirsutum	12 g ac/ha	55 g ac/ha	
		Zea mays	46 g ac/ha	120 g ac/ha	
		Cyperus esculentus	72 g ac/ha	240 g ac/ha	
		Pinus elliottii	19 g ac/ha	293 g ac/ha	
		Pterydium aquilinium	156 g ac/ha	485 g ac/ha	
		Allium cepa	247 g ac/ha	511 g ac/ha	
		Wordardia virginica	19 g ac/ha	538 g ac/ha	
	Wisconsin	*Cyperus esculentus*	18 g ac/ha	35 g ac/ha	Bellet 1990b
		Helianthus annuus	31 g ac/ha	63 g ac/ha	
		Allium cepa	36 g ac/ha	74 g ac/ha	
		Pinus strobes	74 g ac/ha	150 g ac/ha	
		Glycine max	395 g ac/ha	191 g ac/ha	
		Zea mays	216 g ac/ha	539 g ac/ha	
		Phaseolus vulgaris	393 g ac/ha	884 g ac/ha	

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 55). 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 56 for wild mammals; Table 57 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 55: Seasonal exposure estimates for diquat in animal food items

Category	EFSA 2009 crop group	Situation	Application rate & frequency	FFT	Seasonal exposure rate (g/ha) [39]
					Maximum
Pre-harvest crop desiccation	Cereals	Cereals, rice	From 1× 600 g ac/ha	1.0	600
	Cotton	Cotton	From 1× 600 g ac/ha	1.0	600
	Legume forage	Lucerne, lupins	From 1× 600 g ac/ha	1.0	600

[39] Seasonal exposure rates assume a maximum of 40% of the area is treated for spot spraying uses, and are adjusted accordingly

Category	EFSA 2009 crop group	Situation	Application rate & frequency	FFT	Seasonal exposure rate (g/ha) [39]
					Maximum
	Maize [40]	Sugarcane	From 1× 600 g ac/ha	1.0	600
		Sugarcane (hand spraying)	1× 200 g ac/ha	0.4	80
	Oilseeds	Poppies	From 1× 800 g ac/ha	1.0	800
		Oilseeds	From 1× 600 g ac/ha	1.0	600
	Potatoes	Potatoes (haulm desiccation), sweet potatoes	From 1× 800 g ac/ha	1.0	800
		Potatoes (pre-harvest)	1× 300 g ac/ha	1.0	300
	Pulses	Pulses	From 1× 600 g ac/ha	1.0	600
	Sunflower	Sunflower	From 1× 600 g ac/ha	1.0	600
General weed control	Bare soil	Market gardens, row crops, vegetables	From 1× 800 g ac/ha	1.0	800
		Market gardens, row crops, vegetables (shielded inter-row spraying)	From 1× 800 g ac/ha	1.0 [41]	800
		Oilseed poppies	From 1× 300 g ac/ha	1.0	300
		Hops	From 1× 280 g ac/ha	1.0	280

[40] 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.

[41] 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 & frequency	FFT	Seasonal exposure rate (g/ha) [39]
					Maximum
		Hops (directed inter-row spraying)	From 1× 280 g ac/ha	0.4	112
		Asparagus	1× 280 g ac/ha	1.0	280
	Cereals	Cereals (pre-harvest)	From 1× 600 g ac/ha	1.0	600
		Cereals (up to tillering)	From 1× 140 g ac/ha	1.0	140
	Grassland	Pasture (grazed before spraying)	From 1× 300 g ac/ha	1.0	300
		Infested areas	1× 560 g ac/ha	1.0	560
		Infested areas (knapsack sprayer and spot spraying)	From 1× 1333 g ac/ha	0.4	533
	Legume forage	Lucerne (grazed before spraying) [42]	From 1× 140 g ac/ha	1.0	140
	Orchards	Orchards	1× 300 g ac/ha	1.0	300
		Orchards (directed spray under trees and inter-row spraying)	1× 300 g ac/ha	0.4	120
	Vineyards	Vineyards	1× 300 g ac/ha	1.0	300
		Vineyards (directed spray under vines and inter-row spraying)	1× 300 g ac/ha	0.4	120
Combination products containing	Bare soil	Fallow (minimal disturbance)	From 2× 368 g ac/ha 7d interval	1.0	595

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

Category	EFSA 2009 crop group	Situation	Application rate & frequency	FFT	Seasonal exposure rate (g/ha) [39]
					Maximum
paraquat		Fallow (minimal disturbance)	From 1× 368 g ac/ha	1.0	368
		Fallow (full disturbance)	From 1× 276 g ac/ha	1.0	276
		Market gardens, nurseries, potatoes (pre/early-emergence), rice (pre-emergence), vegetables	From 1× 368 g ac/ha	1.0	368
		Spot spray in market gardens, nurseries, potatoes (pre/early emergence)	From 1× 368 g ac/ha	0.4	147
	Cotton	Cotton desiccant	From 1× 184 g ac/ha	1.0	184
	Grassland	Public service areas, rights of way, pasture	From 1× 368 g ac/ha	1.0	368
		Spot spray in public service areas, rights of way	From 1× 368 g ac/ha	0.4	147
		Hay freezing	1× 173 g ac/ha	1.0	173
	Legume forage	Lucerne (grazed before spraying)	From 1× 276 g ac/ha	1.0	276
	Maize	Sugarcane (over the top spray)	From 1× 230 g ac/ha	1.0	230
		Sugarcane (inter-row spray)	From 1× 230 g ac/ha	1.0	230
	Potatoes	Potatoes (pre-harvest)	1× 368 g ac/ha	1.0	368
		Spot spray in potatoes (pre-harvest)	1× 368 g ac/ha	0.4	147
	Orchards	Forests, orchards, plantations, bananas, duboisia, tea tree	From 1× 368 g ac/ha	1.0	368
		Spot application in orchards, plantations, bananas, duboisia	From 1× 368 g ac/ha	0.4	147

Category	EFSA 2009 crop group	Situation	Application rate & frequency	FFT	Seasonal exposure rate (g/ha) [39]
					Maximum
		Spot application in avocado, custard apples, lychees, mangos [43]	From 2× 276 g ac/ha 14d interval	0.4	152
	Vineyards	Vineyards	From 1× 368 g ac/ha	1.0	368
		Spot application in vineyards	From 1× 368 g ac/ha	0.4	147

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 = 0.4 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

Table 56: Assessment of risks to wild mammals (acute RAL 21 mg/kg bw; chronic RAL 4.0 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, market gardens, nurseries, potatoes (early/pre-emergence), rice, row crops, vegetables, oilseeds, hops, asparagus	Bare soil	Small omnivore	BBCH <10	14.3	5.7	1469	2664
General weed	Cereals	Large herbivore	Early (shoots)	42.1	22.3	499	681

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

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
control in cereals (up to tillering)		Small omnivore	BBCH 10-29	17.2	7.8	1221	1947
		Small insectivore	BBCH 10-19	7.6	4.2	2763	3616
General weed control in cereals (pre-harvest)	Cereals	Small herbivore	BBCH ≥40	40.9	21.7	513	700
		Small omnivore	BBCH ≥40	5.2	2.3	4038	6603
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
Pre-harvest desiccation in cereals and rice	Cereals	Small herbivore	BBCH ≥40	40.9	21.7	513	700
		Small omnivore	BBCH ≥40	5.2	2.3	4038	6603
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
Pre-harvest desiccation in cotton	Cotton	Small herbivore	BBCH ≥50	34.1	18.1	616	839
		Small omnivore	BBCH ≥50	4.3	1.9	4884	7993
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
General weed control in infested areas, hay freezing, pasture, public service areas, rights of way	Grassland	Small herbivore	All season	136.4	72.3	154	210
		Large herbivore	All season	32.6	17.3	644	878
		Small omnivore	New sown or late season	14.4	6.6	1458	2301
		Small insectivore	Late season	5.4	1.9	3889	7993
General weed control in lucerne (grazed before application)	Legume forage	Small omnivore	BBCH 10-49	17.2	7.8	1221	1947
		Small insectivore	BBCH 10-19	7.6	4.2	2763	3616
Pre-harvest desiccation in lucerne and lupins	Legume forage	Small herbivore	BBCH ≥50	40.9	21.7	513	700
		Small omnivore	BBCH ≥50	5.2	2.3	4038	6603

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
General weed control in sugarcane (over the top spray and inter-row spray)	Maize	Small herbivore	BBCH 10-29	136.4	72.3	154	210
		Small omnivore	BBCH 10-29	17.2	7.8	1221	1947
		Small insectivore	BBCH 10-19	7.6	4.2	2763	3616
Pre-harvest desiccation in sugarcane	Maize	Small herbivore	BBCH ≥40	34.1	18.1	616	839
		Small omnivore	BBCH ≥40	4.3	1.9	4884	7993
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
Pre-harvest desiccation in poppies and oilseeds	Oilseeds	Small herbivore	BBCH ≥40	34.1	18.1	616	839
		Large herbivore	All season	35.1	14.3	598	1062
		Small omnivore	BBCH ≥40	4.3	1.9	4884	7993
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
General weed control in bananas, duboisia, forests, orchards, plantations, tea tree, and tropical fruits	Orchards	Small herbivore	Ground directed	136.4	72.3	154	210
		Large herbivore	Ground directed	35.1	14.3	598	1062
		Small omnivore	Ground directed	17.2	7.8	1221	1947
		Small insectivore	Ground directed	5.4	1.9	3889	7993
Pre-harvest desiccation in potatoes	Potatoes	Small herbivore	BBCH ≥40	40.9	21.7	513	700
		Large herbivore	BBCH ≥40	10.5	4.3	2000	3532
		Small omnivore	BBCH ≥40	5.2	2.3	4038	6603

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
General weed control in potatoes (pre-harvest)	Potatoes	Small herbivore	BBCH ≥40	40.9	21.7	513	700
		Large herbivore	BBCH ≥40	10.5	4.3	2000	3532
		Small omnivore	BBCH ≥40	5.2	2.3	4038	6603
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
Pre-harvest desiccation in pulses	Pulses	Small herbivore	BBCH ≥50	40.9	21.7	513	700
		Large herbivore	BBCH ≥50	10.5	4.3	2000	3532
		Small omnivore	BBCH ≥50	5.2	2.3	4038	6603
			BBCH 81-99	14.4	6.6	1458	2301
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
Pre-harvest desiccation in sunflower	Sunflower	Small herbivore	BBCH ≥40	34.1	18.1	616	839
		Large herbivore	BBCH ≥40	8.8	3.6	2386	4219
		Small omnivore	BBCH ≥40	4.3	1.9	4884	7993
		Small insectivore	BBCH ≥20	5.4	1.9	3889	7993
General weed control in vineyards	Vineyards	Small herbivore	Ground directed	136.4	72.3	154	210
		Large herbivore	Ground directed	27.2	11.1	772	1368
		Small omnivore	Ground directed	17.2	7.8	1221	1947

Crop groups and situations as indicated in Table 55

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

RAL = regulatory acceptable level

Acute = LD_{50} 208 mg/kg bw (Rittenhouse 1979, McCall & Robinson 1990) and assessment factor of 10

Chronic = NOAEL 4.0 mg/kg bw/d (Hodge 1990) 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 55. Therefore, further refinement would be required to demonstrate an acceptable risk for one or more on-label use rates.

Table 57: Assessment of risks to birds (acute RAL 7.0 mg/kg bw; chronic RAL 3.2 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, market gardens, nurseries, potatoes (early/pre-emergence), rice, row crops, vegetables, oilseeds, hops, asparagus	Bare soil	Small granivore	BBCH <10	24.7	11.4	283	1066
		Small omnivore	BBCH <10	17.4	8.2	402	1482
		Small insectivore	BBCH <10	10.9	5.9	642	2059
General weed control in cereals (up to tillering)	Cereals	Large herbivore	BBCH 10-29	30.5	16.2	230	750
		Small omnivore	BBCH 10-29	24.0	10.9	292	1115
General weed control in cereals (pre-harvest)	Cereals	Small insectivore	BBCH 71-89	57.6	22.4	122	542
		Small omnivore	BBCH ≥40	7.2	3.3	972	3682
		Small granivore/ insectivore	Late season	27.0	12.5	259	972
Pre-harvest desiccation in cereals and rice	Cereals	Small insectivore	BBCH 71-89	57.6	22.4	122	542
		Small omnivore	BBCH ≥40	7.2	3.3	972	3682
		Small granivore/ insectivore	Late season	27.0	12.5	259	972
Pre-harvest desiccation in cotton	Cotton	Medium insectivore	BBCH ≥20	3.0	1.1	2333	11045
		Small omnivore	BBCH ≥50	4.4	2.8	1591	4339
General weed	Grassland	Small granivore	Late season	24.7	11.4	283	1066

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
control in infested areas, hay freezing, pasture, public service areas, rights of way		Large herbivore	Growing shoots	30.5	16.2	230	750
		Small insectivore	Growing shoots	26.8	11.3	261	1075
General weed control in lucerne (grazed before application)	Legume forage	Small granivore	BBCH 10-49	24.7	11.4	283	1066
		Small omnivore	BBCH 10-49	24.0	10.9	292	1115
		Small insectivore	BBCH 10-19	26.8	11.3	261	1075
Pre-harvest desiccation in lucerne and lupins	Legume forage	Small granivore	BBCH ≥50	7.4	3.4	946	3574
		Small omnivore	BBCH ≥50	7.2	3.3	972	3682
		Small insectivore	BBCH ≥20	25.2	9.7	278	1253
General weed control in sugarcane (over the top spray and inter-row spray)	Maize	Medium herbivore/ granivore	BBCH 10-29	55.6	22.7	126	535
		Medium granivore	BBCH 10-29	6.6	3.0	1061	4050
		Small omnivore	BBCH 10-29	24.0	10.9	292	1115
		Small insectivore	BBCH 10-19	26.8	11.3	261	1075
		Small insectivore/worm feeding	BBCH 10-19	10.5	5.7	667	2132
Pre-harvest desiccation in sugarcane	Maize	Medium granivore	BBCH ≥40	1.6	0.8	4375	15187
		Small omnivore	BBCH ≥40	6.0	2.7	1167	4500
		Medium herbivore/granivore	BBCH ≥40	13.9	5.7	504	2132
		Small insectivore	BBCH ≥20	12.6	4.8	556	2531
Pre-harvest	Oilseeds	Small granivore	BBCH 80-99	24.7	11.4	283	1066

Situation	Crop group	Generic focal species	Crop stage	Shortcut value		Acceptable rate (g ac/ha)	
				acute	chronic	acute	chronic
desiccation in poppies and oilseeds		Small omnivore	BBCH ≥40	6.0	2.7	1167	4500
		Medium herbivore/granivore	BBCH ≥40	2.0	0.9	3500	13500
		Small insectivore	BBCH 30-99	7.4	2.7	946	4500
General weed control in bananas, duboisia, forests, orchards, plantations, tea tree, tropical fruits and vineyards	Orchards	Small granivore	Ground directed	27.4	12.6	255	964
		Small insectivore/worm feeding	Ground directed	7.4	2.7	946	4500
General weed control in potatoes (pre-harvest)	Potatoes	Small omnivore	BBCH ≥40	7.2	3.3	972	3682
		Small insectivore	BBCH ≥20	25.2	11.3	278	1253
Pre-harvest desiccation in potatoes	Potatoes	Small omnivore	BBCH ≥40	7.2	3.3	972	3682
		Small insectivore	BBCH ≥20	25.2	11.3	278	1253
Pre-harvest desiccation in pulses	Pulses	Small granivore	BBCH ≥50	7.4	3.4	946	3574
		Small omnivore	BBCH ≥50	7.2	3.3	972	3682
		Small insectivore	BBCH ≥20	25.2	9.7	278	1253
Pre-harvest desiccation in sunflower	Sunflower	Small granivore/ insectivore	BBCH 61-92	21.7	10.0	323	1215

Crop groups and situations as indicated in Table 55

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

RAL = regulatory acceptable level

Acute = geomean LD50 70 mg/kg bw (Fink et al. 1982, Hubbard 2013, Roberts & Fairley 1980) and assessment factor of 10

Chronic = NOEL 3.2 mg/kg bw/d (Temple et al. 2004a, 2004b) 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 55. 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 – DT_{50} values of 2.2 d for insects, 1.6 d for foliage and 7.9 d for seeds have been established, they will be used to refine the MAF and TWA for relevant food items where appropriate.
- Sunflowers – Shortcut value adjusted to account for measured energy efficiency, moisture content and assimilation efficiency.

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 58 for wild mammals; Table 59 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 58: Refined assessment of risks to wild mammals (acute RAL 21 mg/kg bw; chronic RAL 4.0 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 cereals (pre-harvest)												
Cereals	Small herbivore	BBCH ≥40	Acute	11.2[a,c]	600	1.0	1.0	1.0	6.7	21	0.32	1875
				11.2[a,c]	400	1.0	1.0	1.0	4.5	21	0.21	1875
Pre-harvest desiccation in cereals and rice												
Cereals	Small herbivore	BBCH ≥40	Acute	11.2[a,c]	600	1.0	1.0	1.0	6.7	21	0.32	1875
General weed control in infested areas, hay freezing, pasture, public service areas, rights of way												
Grassland	Small herbivore	All season	Acute	112[a]	560	1.0	1.0	1.0	63	21	**3.0**	188
				112[a]	533	1.0	1.0	1.0	60	21	**2.8**	188
				112[a]	368	1.0	1.0	1.0	41	21	**2.0**	188
				112[a]	276	1.0	1.0	1.0	31	21	**1.5**	188

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				112[a]	184	1.0	1.0	1.0	21	21	0.98	188
				112[a]	173	1.0	1.0	1.0	19	21	0.92	188
				112[a]	138	1.0	1.0	1.0	15	21	0.74	188
				112[a]	92	1.0	1.0	1.0	10	21	0.49	188
				112[a]	24	1.0	1.0	1.0	2.7	21	0.13	188
	Small herbivore	All season	Chronic	59.3[a]	560	1.0	0.5	0.11[d]	1.8	4.0	0.46	1226
				59.3[a]	533	1.0	0.5	0.11[d]	1.7	4.0	0.43	1226
				59.3[a]	368	1.0	0.5	0.11[d]	1.2	4.0	0.30	1226
				59.3[a]	276	1.0	0.5	0.11[d]	0.90	4.0	0.23	1226
				59.3[a]	184	1.0	0.5	0.11[d]	0.60	4.0	0.15	1226
				59.3[a]	173	1.0	0.5	0.11[d]	0.56	4.0	0.14	1226
				59.3[a]	138	1.0	0.5	0.11[d]	0.45	4.0	0.11	1226
				59.3[a]	92	1.0	0.5	0.11[d]	0.30	4.0	0.08	1226
				59.3[a]	24	1.0	0.5	0.11[d]	0.078	4.0	0.02	1226
Pre-harvest desiccation in lucerne and lupins												
Legume forage	Small herbivore	BBCH ≥50	Acute	16.8[a,c]	600	1.0	1.0	1.0	10	21	0.48	1250
General weed control in sugarcane (over the top spray and inter-row spray)												
Maize	Small herbivore	BBCH 10-29	Acute	112[a]	230	1.0	1.0	1.0	26	21	**1.2**	188
				112[a]	184	1.0	1.0	1.0	21	21	0.98	188
	Small herbivore	BBCH 10-29	Chronic	59.3[a]	230	1.0	0.5	0.11[d]	0.75	4.0	0.19	1226
				59.3[a]	184	1.0	0.5	0.11[d]	0.60	4.0	0.15	1226
Pre-harvest desiccation in poppies and oilseeds												
Oilseeds	Small herbivore	BBCH ≥40	Acute	22.4[a,c]	800	1.0	1.0	1.0	18	21	0.85	938
				22.4[a,c]	600	1.0	1.0	1.0	13	21	0.64	938
	Large herbivore	All season	Acute	22.2[b]	800	1.0	1.0	1.0	18	21	0.85	946
				22.2[b]	600	1.0	1.0	1.0	13	21	0.63	946
General weed control in bananas, duboisia, forests, orchards, plantations, tea tree, and tropical fruits												
Orchards	Small herbivore	Ground directed	Acute	112[a]	368	1.0	1.0	1.0	41	21	**2.0**	188
				112[a]	300	1.0	1.0	1.0	34	21	**1.6**	188
				112[a]	152	1.0[d]	1.0	1.0	17	21	0.81	188
				112[a]	147	1.0	1.0	1.0	16	21	0.78	188
				112[a]	120	1.0	1.0	1.0	13	21	0.64	188
				112[a]	110	1.0	1.0	1.0	12	21	0.59	188
	Small herbivore	Ground directed	Chronic	59.3[a]	368	1.0	0.5	0.11[d]	1.2	4.0	0.30	1226
				59.3[a]	300	1.0	0.5	0.11[d]	1.0	4.0	0.24	1226

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				59.3[a]	152	1.0[d]	0.5	0.11[d]	0.50	4.0	0.12	1226
				59.3[a]	147	1.0	0.5	0.11[d]	0.48	4.0	0.12	1226
				59.3[a]	120	1.0	0.5	0.11[d]	0.39	4.0	0.10	1226
				59.3[a]	110	1.0	0.5	0.11[d]	0.36	4.0	0.090	1226
Pre-harvest desiccation in potatoes												
Potatoes	Small herbivore	BBCH ≥40	Acute	16.8[a,c]	800	1.0	1.0	1.0	13	21	0.64	1250
				16.8[a,c]	300	1.0	1.0	1.0	5.0	21	0.24	1250
	Small herbivore	BBCH ≥40	Chronic	8.9[a,c]	800	1.0	0.5	0.11[d]	0.39	4.0	0.10	8172
				8.9[a,c]	300	1.0	0.5	0.11[d]	0.15	4.0	0.037	8172
Pre-harvest desiccation in pulses												
Pulses	Small herbivore	BBCH ≥50	Acute	33.6[a]	600	1.0	1.0	1.0	20	21	0.96	625
General weed control in vineyards												
Vineyards	Small herbivore	Ground directed	Acute	112[a]	368	1.0	1.0	1.0	41	21	**2.0**	188
				112[a]	300	1.0	1.0	1.0	34	21	**1.6**	188
				112[a]	171	1.0	1.0	1.0	19	21	0.91	188
				112[a]	147	1.0	1.0	1.0	16	21	0.78	188
				112[a]	120	1.0	1.0	1.0	13	21	0.64	188
	Small herbivore	Ground directed	Chronic	59.3[a]	368	1.0	0.5	0.11[d]	1.2	4.0	0.30	1226
				59.3[a]	300	1.0	0.5	0.11[d]	1.0	4.0	0.24	1226
				59.3[a]	171	1.0	0.5	0.11[d]	0.56	4.0	0.14	1226
				59.3[a]	147	1.0	0.5	0.11[d]	0.48	4.0	0.12	1226
				59.3[a]	120	1.0	0.5	0.11[d]	0.39	4.0	0.10	1226

[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} 1.6 d for foliar food items

Crop groups and situations as indicated in Table 55

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 61)

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 = LD_{50} 208 mg/kg bw (Rittenhouse 1979, McCall & Robinson 1990) and assessment factor of 10

Chronic = NOAEL 4.0 mg/kg bw/d (Hodge 1990) 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 59: Refined assessment of risks to birds (acute RAL 7.0 mg/kg bw; chronic RAL 3.2 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, market gardens, nurseries, potatoes (early/pre-emergence), rice, row crops, vegetables, oilseeds, hops, asparagus												
Bare soil	Small granivore	BBCH <10	Acute	24.7	800	1.0	1.0	1.0	20	7.0	2.8	283
				24.7	368	1.0	1.0	1.0	9.1	7.0	1.3	283
				24.7	368	1.5[a]	1.0	1.0	14	7.0	1.9	189
				24.7	300	1.0	1.0	1.0	7.4	7.0	1.1	283
				24.7	280	1.0	1.0	1.0	6.9	7.0	0.99	283
				24.7	276	1.0	1.0	1.0	6.8	7.0	0.97	283
				24.7	276	1.5[a]	1.0	1.0	10	7.0	1.5	189
				24.7	253	1.0	1.0	1.0	6.2	7.0	0.89	283
				24.7	207	1.0	1.0	1.0	5.1	7.0	0.73	283
				24.7	184	1.0	1.0	1.0	4.5	7.0	0.65	283
				24.7	184	1.5[a]	1.0	1.0	6.8	7.0	0.97	189
				24.7	147	1.0	1.0	1.0	3.6	7.0	0.52	283
				24.7	138	1.0	1.0	1.0	3.4	7.0	0.49	283
				24.7	138	1.5[a]	1.0	1.0	5.1	7.0	0.73	189
				24.7	112	1.0	1.0	1.0	2.8	7.0	0.40	283
				24.7	92	1.0	1.0	1.0	2.3	7.0	0.32	283
	Small omnivore	BBCH <10	Acute	17.4	800	1.0	1.0	1.0	14	7.0	2.0	402
				17.4	368	1.0	1.0	1.0	6.4	7.0	0.91	402
				17.4	368	1.3[a]	1.0	1.0	8.3	7.0	1.2	309
				17.4	300	1.0	1.0	1.0	5.2	7.0	0.75	402
				17.4	280	1.0	1.0	1.0	4.9	7.0	0.70	402
				17.4	276	1.0	1.0	1.0	4.8	7.0	0.69	402
				17.4	276	1.3[a]	1.0	1.0	6.2	7.0	0.89	309
				17.4	253	1.0	1.0	1.0	4.4	7.0	0.63	402
				17.4	207	1.0	1.0	1.0	3.6	7.0	0.51	402
				17.4	184	1.0	1.0	1.0	3.2	7.0	0.46	402
				17.4	184	1.3[a]	1.0	1.0	4.2	7.0	0.59	309
				17.4	147	1.0	1.0	1.0	2.6	7.0	0.37	402
				17.4	138	1.0	1.0	1.0	2.4	7.0	0.34	402
				17.4	138	1.3[a]	1.0	1.0	3.1	7.0	0.45	309
				17.4	112	1.0	1.0	1.0	1.9	7.0	0.28	402
				17.4	92	1.0	1.0	1.0	1.6	7.0	0.23	402

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
	Small insectivore	BBCH <10	Acute	10.9	800	1.0	1.0	1.0	8.7	7.0	1.2	642
				10.9	368	1.0	1.0	1.0	4.0	7.0	0.57	642
				10.9	368	1.1[a]	1.0	1.0	4.4	7.0	0.63	584
				10.9	300	1.0	1.0	1.0	3.3	7.0	0.47	642
				10.9	280	1.0	1.0	1.0	3.1	7.0	0.44	642
				10.9	276	1.0	1.0	1.0	3.0	7.0	0.43	642
				10.9	276	1.1[a]	1.0	1.0	3.3	7.0	0.47	584
				10.9	253	1.0	1.0	1.0	2.8	7.0	0.39	642
				10.9	207	1.0	1.0	1.0	2.3	7.0	0.32	642
				10.9	184	1.0	1.0	1.0	2.0	7.0	0.29	642
				10.9	184	1.1[a]	1.0	1.0	2.2	7.0	0.32	584
				10.9	147	1.0	1.0	1.0	1.6	7.0	0.23	642
				10.9	138	1.0	1.0	1.0	1.5	7.0	0.21	642
				10.9	138	1.1[a]	1.0	1.0	1.7	7.0	0.24	584
				10.9	112	1.0	1.0	1.0	1.2	7.0	0.17	642
				10.9	92	1.0	1.0	1.0	1.0	7.0	0.14	642
General weed control in cereals (pre-harvest)												
Cereals	Small insectivore	BBCH 71-89	Acute	57.6	600	1.0	1.0	1.0	35	7.0	4.9	122
				57.6	400	1.0	1.0	1.0	23	7.0	3.3	122
	Small granivore/ insectivore	Late season	Acute	27.0	600	1.0	1.0	1.0	16	7.0	2.3	259
				27.0	400	1.0	1.0	1.0	11	7.0	1.5	259
	Small insectivore	BBCH 71-89	Chronic	22.4	600	1.0	0.5	0.15[a]	1.0	3.2	0.32	1905
				22.4	400	1.0	0.5	0.15[a]	0.7	3.2	0.21	1905
Pre-harvest desiccation in cereals and rice												
Cereals	Small insectivore	BBCH 71-89	Acute	57.6	600	1.0	1.0	1.0	35	7.0	4.9	122
	Small granivore/ insectivore	Late season	Acute	27.0	600	1.0	1.0	1.0	16	7.0	2.3	259
	Small insectivore	BBCH 71-89	Chronic	22.4	600	1.0	0.5	0.15[a]	1.0	3.2	0.32	1905
General weed control in infested areas, hay freezing, pasture, public service areas, rights of way												
Grassland	Small granivore	Late season	Acute	24.7	560	1.0	1.0	1.0	14	7.0	2.0	283
				24.7	533	1.0	1.0	1.0	13	7.0	1.9	283
				24.7	368	1.0	1.0	1.0	9.1	7.0	1.3	283
				24.7	300	1.0	1.0	1.0	7.4	7.0	1.1	283
				24.7	276	1.0	1.0	1.0	6.8	7.0	0.97	283

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
				24.7	184	1.0	1.0	1.0	4.5	7.0	0.65	283
				24.7	173	1.0	1.0	1.0	4.3	7.0	0.61	283
				24.7	150	1.0	1.0	1.0	3.7	7.0	0.53	283
				24.7	147	1.0	1.0	1.0	3.6	7.0	0.52	283
				24.7	138	1.0	1.0	1.0	3.4	7.0	0.49	283
				24.7	92	1.0	1.0	1.0	2.3	7.0	0.32	283
				24.7	24	1.0	1.0	1.0	0.59	7.0	0.085	283
	Large herbivore	Growing shoots	Acute	30.5	560	1.0	1.0	1.0	17	7.0	2.4	230
				30.5	533	1.0	1.0	1.0	16	7.0	2.3	230
				30.5	368	1.0	1.0	1.0	11	7.0	1.6	230
				30.5	300	1.0	1.0	1.0	9.2	7.0	1.3	230
				30.5	276	1.0	1.0	1.0	8.4	7.0	1.2	230
				30.5	184	1.0	1.0	1.0	5.6	7.0	0.80	230
				30.5	173	1.0	1.0	1.0	5.3	7.0	0.75	230
				30.5	150	1.0	1.0	1.0	4.6	7.0	0.65	230
				30.5	147	1.0	1.0	1.0	4.5	7.0	0.64	230
				30.5	138	1.0	1.0	1.0	4.2	7.0	0.60	230
				30.5	92	1.0	1.0	1.0	2.8	7.0	0.40	230
				30.5	24	1.0	1.0	1.0	0.73	7.0	0.10	230
	Small insectivore	Growing shoots	Acute	26.8	560	1.0	1.0	1.0	15	7.0	2.1	261
				26.8	533	1.0	1.0	1.0	14	7.0	2.0	261
				26.8	368	1.0	1.0	1.0	9.9	7.0	1.4	261
				26.8	300	1.0	1.0	1.0	8.0	7.0	1.1	261
				26.8	276	1.0	1.0	1.0	7.4	7.0	1.1	261
				26.8	184	1.0	1.0	1.0	4.9	7.0	0.70	261
				26.8	173	1.0	1.0	1.0	4.6	7.0	0.66	261
				26.8	150	1.0	1.0	1.0	4.0	7.0	0.57	261
				26.8	147	1.0	1.0	1.0	3.9	7.0	0.56	261
				26.8	138	1.0	1.0	1.0	3.7	7.0	0.53	261
				26.8	92	1.0	1.0	1.0	2.5	7.0	0.35	261
				26.8	24	1.0	1.0	1.0	0.64	7.0	0.092	261
General weed control in lucerne (grazed before application)												
Legume forage	Small insectivore	BBCH 10-19	Acute	26.8	276	1.0	1.0	1.0	7.4	7.0	1.1	261
				26.8	184	1.0	1.0	1.0	4.9	7.0	0.70	261
				26.8	140	1.0	1.0	1.0	3.8	7.0	0.54	261
				26.8	70	1.0	1.0	1.0	1.9	7.0	0.27	261

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
Pre-harvest desiccation in lucerne and lupins												
Legume forage	Small insectivore	BBCH ≥20	Acute	25.2	600	1.0	1.0	1.0	15	7.0	2.2	278
General weed control in sugarcane (over the top spray)												
Maize	Medium herbivore/ granivore	BBCH 10-29	Acute	41.7[b]	230	1.0	1.0	1.0	10	7.0	1.4	168
				41.7[b]	184	1.0	1.0	1.0	7.7	7.0	1.1	168
General weed control in sugarcane (inter-row spray)												
Maize	Medium herbivore/ granivore	BBCH 10-29	Acute	55.6	230	1.0	1.0	1.0	13	7.0	1.8	126
				55.6	184	1.0	1.0	1.0	10	7.0	1.5	126
Pre-harvest desiccation in sugarcane												
Maize	Medium herbivore/ granivore	BBCH ≥40	Acute	13.9	600	1.0	1.0	1.0	8.3	7.0	1.2	504
				13.9	200	1.0	1.0	1.0	2.8	7.0	0.40	504
	Small insectivore	BBCH ≥20	Acute	12.6	600	1.0	1.0	1.0	7.6	7.0	1.1	556
				12.6	200	1.0	1.0	1.0	2.5	7.0	0.36	556
Pre-harvest desiccation in poppies and oilseeds												
Oilseeds	Small granivore	BBCH 80-99	Acute	24.7	800	1.0	1.0	1.0	20	7.0	2.8	283
				24.7	600	1.0	1.0	1.0	15	7.0	2.1	283
General weed control in bananas, duboisia, forests, orchards, plantations, tea tree, tropical fruits and vineyards												
Orchards	Small granivore	Ground directed	Acute	15.1[b]	368	1.0	1.0	1.0	5.6	7.0	0.79	464
				15.1[b]	300	1.0	1.0	1.0	4.5	7.0	0.65	464
				15.1[b]	171	1.0	1.0	1.0	2.6	7.0	0.37	464
				15.1[b]	152	1.3[a]	1.0	1.0	3.0	7.0	0.43	357
				15.1[b]	147	1.0	1.0	1.0	2.2	7.0	0.32	464
				15.1[b]	120	1.0	1.0	1.0	1.8	7.0	0.26	464
				15.1[b]	110	1.0	1.0	1.0	1.7	7.0	0.24	464
General weed control in potatoes (pre-harvest)												
Potatoes	Small insectivore	BBCH ≥20	Acute	25.2	368	1.0	1.0	1.0	9.3	7.0	1.3	278
				25.2	147	1.0	1.0	1.0	3.7	7.0	0.53	278
Pre-harvest desiccation in potatoes												
Potatoes	Small insectivore	BBCH ≥20	Acute	25.2	800	1.0	1.0	1.0	20	7.0	2.9	278
				25.2	300	1.0	1.0	1.0	7.6	7.0	1.1	278

Crop group	Generic focal species	Crop stage	Exposure	Shortcut value	AR	MAF	PT	TWA	DDD	RAL	RQ	Max rate
Pre-harvest desiccation in pulses												
Pulses	Small insectivore	BBCH ≥20	Acute	25.2	600	1.0	1.0	1.0	15	7.0	**2.2**	278
Pre-harvest desiccation in sunflower												
Sunflower	Small granivore/ insectivore	BBCH 61-92	Acute	17.4[c]	600	1.0	1.0	1.0	10	7.0	**1.5**	402

[a] Value (MAF or TWA) adjusted to account for DT_{50} values of 2.2 d for insects, 1.6 d for foliage and 7.9 d for seeds

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

[c] Refined shortcut value used for risk assessment; adjusted to account for energy content, assimilation efficiency and moisture content of sunflower seeds (based on Gutiérrez-Expósito et al. 2024)

Crop groups and situations as indicated in Table 55

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 61)

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} 70 mg/kg bw (Fink et al. 1982, Hubbard 2013, Roberts & Fairley 1980) and assessment factor of 10

Chronic = NOEL 3.2 mg/kg bw/d (Temple et al. 2004a, 2004b) 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 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 diquat 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 diquat is included in Table 60. 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 have been considered below the table under the relevant heading.

Table 60: Sources of uncertainty relevant to a weight of evidence argument

<table>
<tr><th>Source of uncertainty</th><th>Relevant taxa</th><th>Discussion</th></tr>
<tr><td rowspan="2">Acute dietary exposure</td><td>Birds</td><td>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 experimental information would be required to establish what magnitude of effect occurs.</td></tr>
<tr><td>Mammals</td><td>Theoretically there may be a difference between dietary and oral dosing. However, reliable experimental information is not available to confirm this or establish the magnitude of any effect.</td></tr>
<tr><td>Indirect mortality</td><td>Birds and mammals</td><td>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 diquat. Diquat exposure can damage the gastrointestinal tract and renal system. 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.</td></tr>
<tr><td>Contact exposure</td><td>Birds and mammals</td><td>Diquat can have toxicological effects due to contact exposure (rat dermal LD_{50} >420 mg ac/kg bw, rabbit dermal LD_{50} 50 mg ac/kg bw). This route of exposure 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.</td></tr>
<tr><td>Avoidance</td><td>Birds and mammals</td><td>Experimental studies addressing avoidance of food treated with diquat have not been submitted or cited during consultation. Extrapolation from data for paraquat (Linder & Richmond, 1990) implies that some food avoidance may occur, at least for mammals, though at what concentration avoidance would occur, or to what degree, has not been demonstrated for diquat.</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 of 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>10th 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>

Source of uncertainty	Relevant taxa	Discussion
Herbicidal mode of action	Birds and mammals	The herbicidal mode of action of diquat may affect exposure in a couple of 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 diquat. 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 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.

Source of uncertainty	Relevant taxa	Discussion
Wildlife monitoring data	Birds and mammals	Several submissions received during the consultation period 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 diquat 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.
Population effects	Birds and mammals	As described in the current APVMA guidance[44], 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. Specific population level analysis 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 diquat 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, market gardens, nurseries, potatoes (early/pre-emergence), rice, row crops, vegetables, oilseeds, hops, asparagus

Mammals – Acceptable risks can be concluded based on the Tier-1 risk assessment (Table 56); no further consideration is required.

Birds – There are unresolved acute risks for small granivorous (at rates >283 g ac/ha or 2 × 189 g ac/ha), small omnivorous (at rates >402 g ac/ha or 2 × 309 g ac/ha) and small insectivorous birds (at rates >642 g ac/ha or 2 × 584 g ac/ha). 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, 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 60) can be considered further. Currently the available information is not considered sufficient to resolve the risk for birds, and an acceptable risk cannot be established for application rates >283 g ac/ha (or 2 × 189 g ac/ha).

Cereal crop group – General weed control in cereals (pre-harvest)

[44] https://www.apvma.gov.au/registrations-and-permits/data-guidelines/risk-assessment-manuals/environment/appendix-a

Mammals – Acceptable risks can be concluded based on the refined risk assessment (Table 58); no further consideration is required.

Birds – There are unresolved acute risks for small insectivorous (at rates >122 g ac/ha), and small granivorous/insectivorous birds (at rates >259 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 60) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 59, and an acceptable risk cannot be established for application rates >122 g ac/ha.

Cereal crop group – Pre-harvest desiccation in cereals and rice

Mammals – Acceptable risks can be concluded based on the refined risk assessment (Table 58); no further consideration is required.

Birds – There are unresolved acute risks for small insectivorous (at rates >122 g ac/ha), and small granivorous/insectivorous birds (at rates >259 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 60) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 59, and an acceptable risk cannot be established for application rates >122 g ac/ha.

Grassland crop group – General weed control in hay freezing and pasture

Mammals – There are unresolved acute risks for small herbivorous mammals (at rates >188 g ac/ha). The RQ values are ≥1.5 at rates ≥276 g ac/ha.

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 60 that would affect the risk to small herbivorous mammals, i.e. the herbicidal mode of action of diquat. 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 3.0).

Birds – There are unresolved acute risks for small granivorous (at rates >283 g ac/ha), large herbivorous (at rates >230 g ac/ha) and small insectivorous birds (at rates >261 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 60) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 59, and an acceptable risk cannot be established for application rates >230 g ac/ha.

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

Mammals – There are unresolved acute risks for small herbivorous mammals (at rates >188 g ac/ha). The RQ values are ≥1.5 at rates ≥276 g ac/ha.

It has been argued during consultation 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. More modest reductions in the treated area (i.e. accepting that ~33% of the area is treated) would be sufficient to resolve the risk for herbivorous mammals. In other cases there will be alternate foraging sites and given the rapid herbicidal action of diquat 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, 560 g ac/ha.

Birds – There are unresolved acute risks for small granivorous (at rates >283 g ac/ha), large herbivorous (at rates >230 g ac/ha) and small insectivorous birds (at rates >261 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. However, 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 therefore concluded to be acceptable based on the weight of evidence at up to the maximum rate proposed for this use type, 560 g ac/ha.

Legume forage crop group – Pre-harvest desiccation in lucerne and lupins

Mammals – Acceptable risks can be concluded based on the refined risk assessment (Table 58); no further consideration is required.

Birds – There are unresolved acute risks for small insectivorous birds (at rates >261 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 60) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 59, and an acceptable risk cannot be established for application rates >261 g ac/ha.

Legume forage crop group – General weed control in lucerne (grazed before application)

Mammals – Acceptable risks can be concluded based on the Tier-1 risk assessment (Table 56); no further consideration is required.

Birds – There are unresolved acute risks for small insectivorous birds (at rates >261 g ac/ha).

For lucerne, submissions during consultation have noted that the majority of lucerne production (83-85%) is geographically restricted to the south-east of South Australia, the distribution of the remaining 15% has not been established. Additionally, threatened species of birds have been cited for this region of Australia. Current product labels are not restricted to South 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 South 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, the exceedance of the RQ (1.1) at the maximum rate is marginal and the intent of the risk assessment is to avoid population level effects. Therefore, the risk is concluded to be acceptable at up to the 276 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 mammals (at rates >188 g ac/ha) [45]. The RQ value is 1.2 at the rate of 230 g ac/ha.

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.

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 diquat 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 [46] the risk to these species can be assumed to be acceptable.

[45] 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.

[46] Implying stable local populations despite current management practices.

Other native rodents [47] 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 [48], 25% seeds and 25% arthropods the RQ would be 0.21 at an application rate of 230 g ac/ha; if the foliar component of the diet were 75% grass the RQ would be 0.38. Treated foliage is only expected to be fully palatable for a short period after treatment (Table 66) 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 diquat from ground-directed applications. There is uncertainty given the current information, but the available information implies that population level effects are not expected.

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[47] *Rattus rattus* and *Mus musculus* were also captured.

[48] Conservative option used given the limitations of the available data, as opposed to non-grass weeds typically assumed for omnivorous mammals.

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 diquat can be considered acceptable at up to the current maximum on-label rate (230 g ac/ha).

Birds – For over-the-top spraying there are unresolved acute risks for medium herbivorous/granivorous birds (at rates >168 g ac/ha). For inter-row spraying there are unresolved acute risks for medium herbivorous/granivorous birds (at rates >126 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 60) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 59, and an acceptable risk cannot be established for application rates >168 g ac/ha (over-the-top spraying) or >126 g ac/ha (interrow spraying).

Maize crop group – Pre-harvest desiccation in sugarcane

Mammals – Acceptable risks can be concluded based on the Tier-1 risk assessment (Table 56), no further consideration is required.

Birds – There are unresolved acute risks for medium herbivorous/granivorous birds (at rates >504 g ac/ha) and small insectivorous birds (at rates >556 g ac/ha). However, the exceedance of the RQ (max 1.2) at the maximum rate is marginal, and the intent of the risk assessment is to avoid population level effects. Therefore, the risk is concluded to be acceptable at up to the 600 g ac/ha.

Oilseeds crop group – Pre-harvest desiccation in poppies and oilseeds

Mammals – Acceptable risks can be concluded based on the refined risk assessment (Table 58); no further consideration is required.

Birds – There are unresolved acute risks for small granivorous birds (at rates >283 g ac/ha).

For Tasmania, potentially relevant species of granivorous birds [49] have been identified – these species are relevant for preharvest desiccation in poppies at up to 800 g ac/ha. At Tier-1 the default body weight for granivorous birds foraging in oilseeds is 15.3 g. Amongst the granivorous bird species considered native to Tasmania [50] body weight estimates are all ≥45 g, the smallest species being *Neophema chrysogaster* (Orange-bellied parrot). For *N.*

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[49] *Neophema chrysostoma, Coturnix ypsilophora, Platycerus eximius, Cacatua roseicapilla, Platycercus caledonicus, Pezoporus wallicus, Neophema chrysogaster, Turnix varia, Cinclosoma punctatum, Coturnix pectoralis, Cacatua galerita, Lathamus discolor, Calyptorhynchus funereus, Melopsittacus undulatus, Lophortyx californicus, Nymphicus hollandicus, Carduelis carduelis, Carduelis chloris, Cacatua sanguinea, Cacatua tenuirostris, Columba livia, Streptopelia chinensis*

[50] *Neophema chrysostoma, Coturnix ypsilophora, Platycerus eximius, Cacatua roseicapilla, Platycercus caledonicus, Pezoporus wallicus, Neophema chrysogaster, Turnix varia, Cinclosoma punctatum, Coturnix pectoralis, Cacatua galerita, Lathamus discolor, Calyptorhynchus funereus*

chrysogaster at an application rate of 800 g ac/ha and with an acute shortcut value of 11.4 [51] the RQ would be 1.3 for an acute exposure. This indicates a marginally unacceptable risk (RQ ≤1.0 indicates an acceptable risk). However, the predicted exposure is expected to be overestimated; interception will reduce deposition on seeds on the ground and seeds in the seed capsules will also be protected from spray deposition [52]. Therefore, the risk can be concluded to be acceptable for all relevant native Tasmanian bird species. Non-native birds such as *Carduelis chloris* (European greenfinch) and *Carduelis carduelis* (European goldfinch) and *Melopsittacus undulatus* (budgerigar) [53] are expected to have lower body weight (14-40 g depending on the species) than *N. chrysogaster*. The same uncertainty over the true exposure for granivores foraging in late season poppy crops also applies, and given that these are not native species the risk is concluded to be acceptable.

The above argument only applies to use in Tasmania; in other situations the risk remains unresolved.

Orchard crop group – General weed control in bananas, duboisia, forests, orchards, plantations, tea tree, and tropical fruits

Mammals – There are unresolved acute risks for small herbivorous mammals (at rates >188 g ac/ha). The RQ values are ≥1.6 at rates ≥300 g ac/ha.

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 60 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 2.0).

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 orchards 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 >188 g ac/ha.

Birds – Acceptable risks can be concluded based on the refined risk assessment (Table 59); no further consideration is required.

Potatoes crop group – General weed control in potatoes (pre-harvest) and pre-harvest desiccation in potatoes

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[51] This is based on a body weight of 45 g, daily energy expenditure 88 KJ/d (for non-passerine birds), 100% weed seed in the diet, assimilation efficiency 76% (based on columbiformes in the absence of data for psittaciformes), food energy 21.7 kJ/g dw, moisture content 9.9% and a 90th percentile RUD of 87 mg/kg

[52] Exposure would be expected primarily when opening the seed capsule. Diquat is not expected to translocate from the seed capsule exterior to the seeds.

[53] Native to mainland Australia only

Mammals – Acceptable risks can be concluded based on the Tier-1 (Table 56) or refined risk assessment (Table 58); no further consideration is required.

Birds – There are unresolved acute risks for small insectivorous birds (at rates >278 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 60) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 65, and an acceptable risk cannot be established for application rates >278 g ac/ha.

Pulses crop group – Pre-harvest desiccation in pulses

Mammals – Acceptable risks can be concluded based on the refined risk assessment (Table 58); no further consideration is required.

Birds – There are unresolved acute risks for small insectivorous birds (at rates >278 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 60) are not considered sufficient to resolve the risk. Therefore, the conclusion of the risk assessment is unchanged from the refined assessment presented in Table 59, and an acceptable risk cannot be established for application rates >278 g ac/ha.

Sunflower crop group – Pre-harvest desiccation in sunflower

Mammals – Acceptable risks can be concluded based on the Tier-1 risk assessment (Table 56); no further consideration is required.

Birds – There are unresolved acute risks for small granivorous/insectivorous birds (at rates >402 g ac/ha). The assessment (Table 59) has been updated to reflect assimilation efficiency, moisture content and energy content of sunflower seeds. Generic weight-of-evidence arguments (Table 60) are not considered sufficient to resolve the risk. Therefore, an acceptable risk cannot be established for application rates >402 g ac/ha.

Vineyard crop group – General weed control in vineyards

Mammals – There are unresolved acute risks for small herbivorous mammals (at rates >188 g ac/ha). The RQ values are ≥1.6 at rates ≥300 g ac/ha.

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 60 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 2.0).

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 vineyards 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 in unacceptable at rates >188 g ac/ha.

Birds – Acceptable risks can be concluded based on the refined risk assessment (Table 59); no further consideration is required.

Conclusions

The risk assessment conclusions, based on the risk assessment in the preceding sections, are summarised in Table 61. Note that this summary is only relevant for the risk from diquat in isolation and does not account for combination toxicity. Furthermore, 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.

Table 61: Risk assessment conclusions for terrestrial vertebrates

Use pattern	EFSA 2009 crop group	Situation	Maximum application rate & frequency [54]	Birds		Mammals	
				Risk acceptable [55]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
Pre-harvest crop desiccation	Cereals	Cereals, rice	From 1× 600 g ac/ha	No	122	Yes	1875
	Cotton	Cotton	From 1× 600 g ac/ha	Yes	1591	Yes	610
	Legume forage	Lucerne, lupins	From 1× 600 g ac/ha	No	278	Yes	1250
	Maize	Sugarcane	From 1× 600 g ac/ha	Yes	600 (WOE)	Yes	610
		Sugarcane (hand spraying)	1× 200 g ac/ha	Yes	504	Yes	610
	Oilseeds	Poppies	From 1× 800 g ac/ha	Yes	800 (WOE)	Yes	938
		Oilseeds	From 1× 600 g ac/ha	No	283	Yes	938
	Potatoes	Potatoes (haulm desiccation), sweet potatoes	From 1× 800 g ac/ha	No	278	Yes	1250
		Potatoes (pre-harvest)	1× 300 g ac/ha	No	278	Yes	1250
	Pulses	Pulses	From 1× 600 g ac/ha	No	278	Yes	625

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

[55] 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 75.

Use pattern	EFSA 2009 crop group	Situation	Maximum application rate & frequency [54]	Birds		Mammals	
				Risk acceptable [55]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
	Sunflower	Sunflower	From 1× 600 g ac/ha	No	323	Yes	610
General weed control	Bare soil	Market gardens, row crops, vegetables	From 1× 800 g ac/ha	No	283	Yes	1455
		Market gardens, row crops, vegetables (shielded inter-row spraying)	From 1× 800 g ac/ha	No	283	Yes	1455
		Oilseeds	From 1× 300 g ac/ha	Yes	300 (WOE). [56]	Yes	1455
		Hops	From 1× 280 g ac/ha	Yes	283	Yes	1455
		Hops (directed inter-row spraying)	From 1× 280 g ac/ha (112 g ac/ha)	Yes	283	Yes	1455
		Asparagus	1× 280 g ac/ha	Yes	283	Yes	1455
	Cereals	Cereals (pre-harvest)	From 1× 600 g ac/ha	No	122	Yes	1875
		Cereals (up to tillering)	From 1× 140 g ac/ha	Yes	230	Yes	494
	Grassland	Pasture (grazed before spraying)	From 1× 300 g ac/ha	No	230	No	188
		Infested areas	1× 560 g ac/ha	Yes	560 (WOE)	Yes	560 (WOE)
		Infested areas (knapsack sprayer and spot spraying)	From 1× 1333 g ac/ha (533 g ac/ha)	Yes	560 (WOE)	Yes	560 (WOE)
	Legume forage	Lucerne (grazed before spraying)	From 1× 140 g ac/ha	Yes	261	Yes	1209
	Orchards	Orchards	1× 300 g ac/ha	Yes	464	No	188
		Orchards (directed spray under trees and inter-row spraying)	1× 300 g ac/ha (120 g ac/ha)	Yes	464	Yes	188
	Vineyards	Vineyards	1× 300 g ac/ha	Yes	464	No	188

[56] WOE argument applies to Tasmania only

Use pattern	EFSA 2009 crop group	Situation	Maximum application rate & frequency [54]	Birds		Mammals	
				Risk acceptable [55]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
		Vineyards (directed spray under vines and inter-row spraying)	1× 300 g ac/ha (120 g ac/ha)	Yes	464	Yes	188
Combination products containing paraquat	Bare soil	Fallow (minimal disturbance)	From 2× 368 g ac/ha 7d interval	No	189	Yes	1455
		Fallow (minimal disturbance)	From 1× 368 g ac/ha	No	283	Yes	1455
		Fallow (full disturbance)	From 1× 276 g ac/ha	No	283	Yes	1455
		Market gardens, nurseries, potatoes (pre/early-emergence), rice (pre-emergence), vegetables	From 1× 368 g ac/ha	No	283	Yes	1455
		Spot spray in market gardens, nurseries, potatoes (pre/early emergence)	From 1× 368 g ac/ha (147 g ac/ha)	Yes	283	Yes	1455
	Cotton	Cotton desiccant	From 1× 184 g ac/ha	Yes	1591	Yes	610
	Grassland	Public service areas, rights of way	From 1× 368 g ac/ha	Yes	560 (WOE)	Yes	560 (WOE)
		Spot spray in public service areas, rights of way	From 1× 368 g ac/ha (147 g ac/ha)	Yes	560 (WOE)	Yes	560 (WOE)
		Pasture	From 1× 368 g ac/ha	No	230	No	188
		Hay freezing	1× 173 g ac/ha	Yes	230	Yes	188
	Legume forage	Lucerne (grazed before spraying)	From 1× 276 g ac/ha	Yes	276 (WOE)	Yes	1209
	Maize	Sugarcane (over the top spray)	From 1× 230 g ac/ha	No	168	Yes	230 (WOE)
		Sugarcane (inter-row spray)	From 1× 230 g ac/ha	No	126	Yes	230 (WOE)
	Potatoes	Potatoes (pre-harvest)	1× 368 g ac/ha	No	278	Yes	509
		Spot spray in potatoes (pre-harvest)	1× 368 g ac/ha (147 g ac/ha)	Yes	278	Yes	509

Use pattern	EFSA 2009 crop group	Situation	Maximum application rate & frequency [54]	Birds		Mammals	
				Risk acceptable [55]	Max. (g ac/ha)	Risk acceptable	Max. (g ac/ha)
	Orchards	Forests, orchards, plantations, bananas, duboisia, tea tree	From 1× 368 g ac/ha	Yes	464	No	188
		Spot application in orchards, plantations, bananas, duboisia	From 1× 368 g ac/ha (147 g ac/ha)	Yes	464	Yes	188
		Spot application in avocado, custard apples, lychees, mangos	From 2× 276 g ac/ha 14d interval (152 g ac/ha)	Yes	357	Yes	188
	Vineyards	Vineyards	From 1× 368 g ac/ha	Yes	464	No	188
		Spot application in vineyards	From 1× 368 g ac/ha (147 g ac/ha)	Yes	464	Yes	188

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:

- 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,

- Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of the Convention.

As diquat is considered to be not readily biodegradable, a weight of evidence approach is followed.

- The photolytic half-life estimates for diquat in freshwater do not exceed 40 days. The DT_{50} was determined to be 2.0 days at 40˚N latitude in summer (Oliver & Webb 2005) and 10 days at 35°N latitude in spring (Dean 2000). Furthermore, a DT_{50} of 11 days was determined in pH 7 buffer under mid-European spring sunlight conditions (Moffatt 1993).
- The degradation half-life of diquat determined in a freshwater sediment simulation study exceeded 180 days. The DT_{50} values were determined to be >1,000 days, under aerobic conditions, in 2 different freshwater systems (Calwich Abbey and Swiss Lake) (Ford et al 2012). Diquat was also considered to be stable in a Florida water/sediment system (Cranor & Daly 1988).
- The degradation half-life of diquat was determined in 3 aerobic studies, which exceeded 180 days in all 9 soils tested (Dixon 2012a, Johnston 1988, Mônego 2006a).

Overall, these results show that the degradation of the substance in freshwater sediment and soil exceeded the persistence threshold. It can thus be concluded that diquat meets the persistence criterion.

Bioaccumulation criterion

The criteria for bioaccumulation in Annex D of the Stockholm Convention are given as follows:

- Evidence that the bioconcentration factor or bioaccumulation factor in aquatic species for the chemical is greater than 5,000 or, in the absence of such data, that the log Pow is greater than 5.
- Evidence that a chemical presents other reasons for concern, such as high bioaccumulation in other species, high toxicity or ecotoxicity.

Or,

- Monitoring data in biota indicating that the bioaccumulation potential of the chemical is sufficient to justify its consideration within the scope of the Convention.

Diquat is not considered to be bioaccumulative based on a fish BCF of 1.0 (Hamer et al. 1987).

Toxicity criterion

The criteria for toxicity in Annex D of the POPs convention are given as follows:

- Evidence of adverse effects to human health or to the environment that justifies consideration of the chemical within the scope of this Convention.

Or,

- Toxicity or ecotoxicity data that indicate the potential for damage to human health or to the environment.

The lowest aquatic long-term effect value of diquat is below 10 µg/L (lowest NOEC is 1.1 µg/L, Ducrot et al. 2010). Therefore, diquat 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:

- Measured levels of the chemical in locations distant from the sources of its release that are of potential concern.
- Monitoring data showing that long-range environmental transport, with the potential for transfer to a receiving environment, (via air, water or migratory species).

Or,

- 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.

Diquat has low vapour pressure, and the modelled atmospheric half-life is <2 days (Hayes 2001); therefore, it is unlikely to travel long distances through the air. There is no evidence to suggest diquat is being transported long distances in the environment.

Conclusion

Diquat does not fulfil the PBT criteria (not PBT) and has low potential for long-range transport. Therefore, diquat 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
AQ1	1-hydroxy- 3,4-dihydro-H-pyrido[1,2-a] pyrazine-2-carboxylic acid
AR	applied radioactivity
BBCH	Biologische Bundesanstalt, Bundessortenamt und CHemische Industrie
BCF	bioconcentration factor
bw	body weight
CCPR	Codex Committee on Pesticide Residues
CI	confidence interval
cm	centimetre(s)
codex	Codex Alimentarius
d	day(s)
DAT	days after treatment
DDD	daily dietary dose
DEE	daily energy expenditure
DEFRA	Department for Environment, Food and Rural Affairs
ds	dry soil or sediment
DT_{50}	period required for 50 percent dissipation
EC_X	concentration causing X% effect (E_rC_X is used for growth rate; E_bC_X is used for biomass; E_yC_X is used for yield)

Shortened term	Full term
ECHA	European Chemicals Agency
EEC	estimated exposure concentration
EFSA	European Food Safety Authority
ER_X	rate causing X% effect
EXP	exponential function
ExpE	exposure estimate
F1	first generation
FE	food energy
FFT	fraction of field treated
F_{int}	interception factor
FIR	Food ingestion rate
g	gram(s)
GAP	Good Agricultural Practice
GIT	gastrointestinal tract
GLP	good laboratory practice
h	hour(s)
ha	hectare(s)
HC_X	hazardous concentration for X% of the species
HR_X	hazardous rate for X% of the species
HR	high residue
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

Shortened term	Full term
LD_X	lethal dose to X% of the tested population
LOC	level of concern
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)
mg/kg bw/day	milligrams per kilogram of bodyweight per day
mL	millilitre(s)
mm	millimetre(s)
mol	mole(s)
mPA	millipascal(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)
OC	organic carbon
OECD	Organisation for Economic Co-operation and Development
Pa	pascals
PBT	persistent – bioaccumulative – toxic
PD	proportion of diet
PEC	predicted environmental concentration
PHI	preharvest interval

Shortened term	Full term
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
RQ	risk quotient
RTR	review technical report
RUD	residue per unit dose
SAC-WB	strong adsorption capacity – wheat bioassay
SDRAM	spray drift risk assessment manual
SSD	species sensitivity distribution
SL	soluble concentrate
SSD	species sensitivity distribution
STMR	Supervised Trials Median Residue
TOPPS	1,2,3,4-tetrahydro-1-oxo-2H-pyrido(1-2-a)-5-pyrazinium salt (R32245, CGA130327)
TWA	time-weighted average
µg	micrograms
USEPA	United States Environmental Protection Agency
UV	ultraviolet
VIS	visible
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
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
aged residue	Residues of a pesticide or its degradates in soil that have diffused into intra-particulate regions following application and have become less accessible to mass transfer and bioabsorption processes, although still amenable to solvent extraction
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)
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
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

Term	Description
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
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
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

Term	Description
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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